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CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

Papers on Hydraulic Engineering. By SAMUEL MCELROY, C. E.

(Continued from page 297.)

No. 1.—RESERVOIR CONSTRUCTION—(Continued).

Theories of Construction.—The object in presenting this rapid sketch of ancient and modern practice, is not for the purpose of describing the several details of arrangement, but rather to illustrate certain general and important principles which have been seriously neglected, and need to be specially recalled.

As to the use of reservoirs, it is obvious for many reasons, which we need not pause to discuss, although involving interesting questions, that between the practice of the ancients and many moderns, in the resort to street fountains, or small house cisterns at low levels, and the system of intermittent supply, as in London, and the service with adequate distribution, under constant pressure, as with us, safety, convenience, and method strongly favor the latter. All the losses which it may involve in supply are fully compensated by attendant benefits, and these may themselves be guarded with proper care.

But the principles of arrangement which we may derive from and add to the practice of the ancients, may properly demand our first attention.

There is a general, and perhaps natural, popular impression, that

water, from our familiarity with its flow in large and small quantities, its common use, its value as a beverage, and its cleansing properties, is easily controlled and confined, and essentially clean and pure; but the engineer who has had to struggle with its enormous weight, its insidious and incessant, or its abrupt and overwhelming energy, its exquisite mobility and its wonderful solvent power, and who has studied the constituents of its natural state and the laws of its purity and impurity, understands the fallacy of this popular idea.

It is evident also, that nothing new has been learned on this subject, in hydraulic theory, and not much improvement has been made in practice, since the Jewish monarch, Hezekiah, distributed, *under pressure*, the supply of Gihon into the city of David. New combinations of old things characterize present professional practice, much of which, as we propose to show, is degenerate.

All hydraulic constructions of the ancients were exceedingly substantial in character, many of them yet remaining in use. Their *castellæ* and *cisternæ*, as their aqueducts, testify to-day of the care exercised in stone and brick, in cement mortar and lining, and in proportions of construction. This may be defined as one prominent characteristic, which illustrates their knowledge of the element they intended to subdue and confine. As a second point, it may be noticed that their aqueducts and reservoirs of all classes were carefully covered; that distinctions in use were made in the qualities of water supplied; and that provisions were made for depuration.

We also observe that the scale of reservoir capacity has been greatly enlarged in modern times, involving a necessary change in materials; and that in the European school, and a few instances with us, reservoirs in earth-work, with artificial slopes, at less than the angle of repose, are protected by substantial water-tight lining. But these instances are rare, being the exceptions to a rule which cannot be approved, and which in practice has universally condemned itself.

The principle of constant service in itself involves the use of reservoirs of great capacity, since the consumers are not prepared for any loss of supply; the use of earth embankments for such reservoirs is in several respects advantageous; and a regard for economy in space and cost favors the use of artificial slopes. As constant service also requires elevated reservoir location, where losses and accidents are enhanced in importance, the question of propriety in construction with us is national. This question has two divisions—proper *stability* and proper *depuration*.

Stability.—All earth-work of artificial slopes in contact with water is exposed to absorption and solution under static pressure, a condition increased by relative head, and is readily disturbed when exposed to water in motion. Either action is injurious, and should be prevented. The solvent and penetrating power of water on an embankment is liable to produce threads and eventual streams of leakage, against which provision must be made. For this purpose puddling is applied. But puddling being in part or wholly composed of clay, is itself pecu-

liarly liable to destruction from water in motion, and hence requires protection; and a very common practice is, to place heavy pyramid walls of it in the centre of embankments, by which the preserver of the earth is to be preserved by earth. This involves an error in principle, since the earth embankment, from its peculiar properties of resistance, is what is relied upon to sustain the enormous thrust of the water prism, and its figure ought not to be thus divided into three distinct bodies and states of body with two distinct kinds of material, of which the face of the centre body is so formed as to thrust the inner embankment towards the foot of the slope, in case it has any tendency to motion from saturation or otherwise. There is no propriety then in placing puddle walls *within* an embankment, for the protection of the embankment, nor is there any propriety in building the base of a puddle wall on the materials it is intended to protect, if such base is not extended over the water floor of the reservoir, so as to prevent leakage precisely where the greatest pressure makes it most apt to occur. Especially is it erroneous to build the foot of a puddle wall on a rock face, along which water readily finds its way; as water joints cannot be made between smooth rock faces, or wood, or iron, and clay, with any degree of certainty.

Evidently, then, the stability of a reservoir of this kind depends, as to this point, on the integrity of its embankments, and these cannot be protected except by absolutely water-tight facing as to the inner slopes, and flooring as to the bottom, and for such facing puddling is not in itself sufficient.

The stability of a reservoir is affected by the relative force and volume of its inlet and outlet currents; by the saturation of its inner slopes, which exposes them to the action of frost, to diminished solidity, to slides, and to leakage; by the action of surface waves, which act as breakers, and are created and affected chiefly by the force and direction of winds, by area or length of travel, by relative shallowness of depth, and to which broken ice at times adds abrasive power; and by the action of muskrats and other animals of the kind. These several actions apply to the bottom, the slopes, and the top angles, as also to the embankment prisms.

The use of dry slope walls is, therefore, defective in principle, since they freely admit the passage of water into the banks, with all the effects of saturation, solvency, currents or waves, which such an open structure cannot but transmit, either to puddling or earth-work, to a greater or less extent. It is only in modification of effect that they are beneficial, and these benefits depend on their thickness and tightness, and the relative power of injury the water may have, under ordinary or extraordinary contact and agitation.

Puddling carefully made, from proper materials, and worked dry, is in itself, as a compact, homogeneous body, admirably adapted for transmitting to the prism slope of an earth embankment on the planes of its surface, when itself properly built or filled, the thrust of the water prism; and when thus laid on the slope, it can be very conveniently and certainly united with the floor covering; hence, the

eminent propriety of its use in this way, and for this purpose. And from the obvious necessity of its protection from the water, follows the use of cement masonry, of solid and durable character, over its entire exposure.

The instances which abound in illustration of this theory of absolute protection, based on the best ancient and modern practice, ought perhaps to be discussed at length, but will be grouped here for the present. Of the list of United States reservoirs presented, only the first four are free from grave objections on this point in construction. When it was attempted in 1854 to draw down the Brookline reservoir, the saturated banks followed the water; when the Hartford reservoir was filled in part, the east bank slid out, forming a new slope, which was in part retained; when Ridgewood reservoir, in 1859, was filled less than 7 feet deep, the surface waves, under March winds, washed out the puddled and earth backing, so as to require the entire rebuilding of a wide belt, before the wall could be subsequently pointed, an event which changed the lining of the new Croton reservoir; in the Manhattan reservoir, as to its walls, a glance reveals the effect on the banks, although changes of water level are rare, and for the system of puddling, occasional rivulets of leakage on the ends, and the necessity of a large sewer on Fifth Avenue, are sufficiently argumentative; the Detroit reservoir, in 1859, which had embankment puddle walls, with a light and imperfect brick face, being drawn down because the upper bank was weakened, brought down the entire embankment face with it, and after considerable consultation, a massive stone abutment was built at the foot of the slope, and a dry stone wall, 6 feet thick at the base and 2·5 feet at the top, carried up, for the ostensible purpose of holding the slope in its place!

From these and other facts, which might be much more fully collated, and which are comments on a simple theory, it may be taken for granted, that no reservoir is properly constructed which is not water-tight in every direction subjected to pressure, and which is not fully protected as to its puddling and earth-work by substantial cement masonry; nor does the fact that such light covering as that of the Belleville, the new Fairmount, and other reservoirs, serves its purpose so far well, justify the hazard which is incurred in its use.

As in slope puddling it is necessary to use thickness enough to make a convenient working width, and as it is advisable in hydraulic work to avoid prolonged bed joints, and as 8 inches of brick masonry can be made much tighter than several times its thickness of stone, while the same thickness does not double the cost, I have preferred to use for reservoir slopes, two feet in puddling, faced with a layer of concrete, and covered with 8-inch brick-work, carefully coped, and adopted this plan for the contract of the Brooklyn Water Works in 1856, covering the bottom with the same thickness of puddling, with 4-inch brick paving, grouted. And with hard-burned paving brick, properly selected and laid in close joints, such lining must prove very satisfactory. The same principle may, however, be fully sustained with carefully built rubble masonry.

Depuration.—Not only does the ancient and the best modern practice use substantial cement masonry in reservoir lining, but with the former, as shown at Rome, Constantinople, Utica, &c., and to an important extent with the latter, as in the new Chelsea Company reservoir, and others which might be adduced in the European school, the water is carefully protected from the sun, and provisions are made for purification by filtration or otherwise.

In all natural water there are three classes of impurities, which differ in different localities, only in degree, and these are, the *mechanical*, the *organic*, or vegetable and animal, and the *mineral*. Chemical science, which has devoted much attention to this subject, and the abundant results of experience have shown, that subsidence corrects the first class of impurities, that æration and fermentation correct the second, while the third may be modified by æration and filtration. From these leading principles we understand at once, that while all reservoirs are depurative by subsidence, as well as by filtration if used, and therefore tend to collect these heavier constituents, none properly fulfil their office in this respect which do not furnish for consumption a surface supply, and their value for subsidence depends on their relative storage and method of use. We also understand that heat, light, and air are the prominent agents on organic matter in water, which is also collected in reservoirs on account of its specific gravity, and that it is therefore advisable to prevent so noxious a condition as direct fermentation to a sensible degree. The third class is not so easily affected, but may be moderated in degree by the remedies for the others.

We see then that subsidence, filtration, circulation or æration, and exclusion of light and heat, are the correct processes for water depuration and preservation, and that the surface currents are of necessity the most pure, while the lower strata are of necessity the most impure. And we therefore comprehend the philosophy of the expensive provisions to these ends, adopted in ancient and modern hydraulic practice. It is a question of great moment to determine how far, in our own school of economical engineering, these provisions are or may be observed.

For the extensive scale of many of our works, the use of covering, which ought never to be cheap and temporary, is almost beyond attainment on the ground of cost; while we know that it would maintain coolness in temperature and freedom from storm waves. It is also plain that filtration by artificial means is in itself an expensive and unsatisfactory process on any large scale, from the necessity of constant renewals, if the process is at all complete in action; although filter beds like those in action at Glasgow and other places are simple in construction, are easily renewed, and do not add over one-half cent cost per thousand gallons for annual operation and interest of capital. The reliance, then, of our own school is confined to subsidence and circulation.

Examining the systems of reservoir construction and use, with us, we have by no means a gratifying series of evidence that due precautions have been exercised in this respect. The use of distinct divisions

is the exception rather than the rule, and very rarely does it occur that consumers are supplied with surface water, which is the purest, but as a general rule, the reverse is the case, and the very process of subsidence carries into the pipes water much more impure than that of the fountain head. In every such case, as to mechanical and other impurities, analysis will show, and has repeatedly shown, this improper effect. Hence the universal necessity of blowing off at the hydrants, the collections at dead-ends, the complaints common to all supplies, of causes independent of oxidation or other difficulties pertaining to distributing mains, and the knowledge in our houses of storms on the works by our drinking glasses.

But, if this neglect is important as to mechanical impurities, it becomes still more so as to those which are organic. These are at all times objectionable, as infusoria, fungoids, fibrous matter, animalcules, and the like, for human imbibing, but become specially so, when advanced by heat and light to a state of sensible fermentation, which is an effort of nature for self-depuration, and which is probably always at work in insensible degrees in all organic solutions.

If it be answered to this statement, that in warm latitudes the water and the sun have greater tendency to this action than with us, the question of degree may be admitted, but the facts in this case, derived from abundant English testimony, and from that of the supplies of our own country, are formidable in their warnings in this respect. At Boston, New Britain, New York, Brooklyn, Albany, Cincinnati, Pittsburgh, Chicago, Cleveland, Savannah, and other places, the records are unmistakable, and by no means of rare occurrence, and they are witnesses of well known chemical laws, which declare, that as all natural water contains organic matter, it needs watchful protection from its incident affections.

From this process of fermentation, which is frequently observed to be at work far below an inoffensive water surface, and from the plain advantages of æration and surface supply, it is sufficiently evident as to the principle of use, that divisions are of great service in all reservoirs, and should be so arranged as to decant surface currents from one to another in succession, and that the use of a bottom supply is a direct violation of correct principle.

We also learn from evident considerations, that shallow reservoirs, and those of disproportionate storage to supply, are objectionable the moment a reasonable capacity for subsidence is passed. The propriety of covering the floors of reservoirs to prevent vegetation, is also affirmed by numerous examples.

If, then, we do not cover our reservoirs, or use filtering chambers, or if we do, it is essential that their contents should be kept from contact with their earth embankments and flooring, that they should be deep and full, that circulation should be promoted by the use of several divisions, and that their supply should never be taken from the bottom; and no supply is, or can be, independent of great need of these simple and plain precautions, under any temperature.

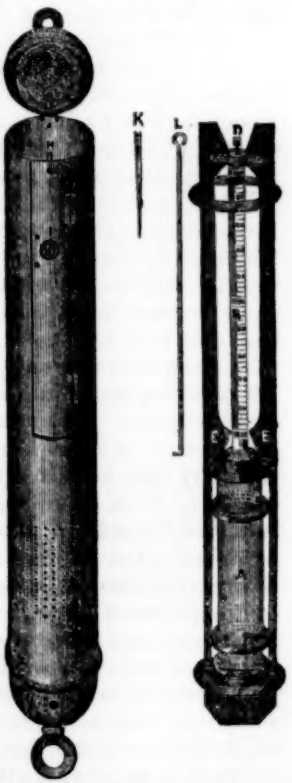
(To be Continued.)

Johnson's Deep-Sea Pressure Gauge.

From the Journal of the Society of Arts, No. 471.

In very deep soundings the pressure of the water is too great to admit of its measurement, except by the use of a body possessing a very slight degree of elasticity.

Mr. Canton, in the year 1761, communicated his observations on the compression of water, which he found to be one part in 21·740, under the pressure of one atmosphere, and in water placed under a receiver, he found an expansion of the same amount, when the air in the receiver was exhausted. Mr. Perkins found a diminution of $\frac{6}{100}$ths of the bulk of water under 1120 atmospheres; that is, about one part in 19,000 for one atmosphere. Water, therefore, possessing this slight degree of elasticity, appears well adapted to determine its pressure at great depths. It is well known that a cork fitted into the neck of a bottle, and lowered in water, will be driven into the body of the bottle if the depth be sufficient; or, if of less depth, that it will be driven down a certain distance, according to the depth to which it is lowered, and that it will as gradually ascend to its original position on being raised to the surface. A gauge made of metal was exhibited last year at the Society of Arts Exhibition of Inventions, and at the meeting of the British Association, reference then being made to the use of glass to vary the experiments, as with metal it is impossible to see when the instrument is free from air bubbles. Mr. Johnson, therefore, had prepared one of glass, which was exhibited by Mr. Glaisher, in Section A, at the last meeting at Manchester.



The instrument now figured is of glass entirely; it consists of a cylindrical glass vessel, with a finely graduated long stem or neck, within which is placed an elastic ring and an elastic stopper; the latter in action pushes the former down the stem, and leaves it at its lowest depression, where it remains acting as an index, whilst the stopper itself again ascends the stem.

In the cut, A is the cylinder; B, stem, with graduated scale; C, flat elastic ring or index; D, elastic stopper; E, metal frame lined with caoutchouc; F, caoutchouc rings, protecting gauge from concussion; G, caoutchouc rings at top and bottom of case, securing the frame in position; H, metal hook on door, securing the top of case; I, clasp to door, let in to avoid pro-

jection; K, "vent" or grooved needle, inserted with stopper; L, brass hook, used to draw up elastic ring.

Some few precautions are necessary to be attended to before use, viz: the vessel must be well rinsed with boiled water, for the purpose of preventing the adhesion of air to its inner surface; next it must be filled with sea-water which has been boiled, and thus freed from air, to exclude all air from the entire vessel and stem.

In this state it is ready for use, and the first step to be taken is to insert the elastic ring and the stopper, with a small grooved needle by its side, thus reserving a small opening for the escape of superfluous water, pressing the stopper so far down the stem, that its lower edge and the first or zero line (marked 2000) on the scale are coincident—then withdraw the grooved needle, and the elastic stopper will tightly fit the stem. To prevent excessive friction of the stopper, it should be slightly lubricated occasionally. On lowering the gauge into water of greater pressure or density than that of the water contained within it, the latter is compressed until it is of the same density as the water by which it is surrounded, and the elastic stopper is pressed down the stem towards the cylinder, at the same time pushing the elastic ring before it. On raising the gauge from water of greater to water of less density, the water contained within the gauge expands, and the elastic stopper is gradually pressed upwards, leaving the elastic ring behind. On arriving at the surface the lower edge of the stopper should be found at zero, and the elastic ring opposite to that division on the graduated stem marking the degree of compression of the water at the greatest depth to which the instrument has been lowered. This depth should be ascertained by the sounding line, to which, at least for some time, the instrument in each experiment should be attached. The mass of water in the cylinder and stem is considered to be divided into 2000 parts, of which the stem contains one-tenth or 200 parts; these are numbered from 1800 to 2000. Each part on the stem may easily be read to a tenth, or 20,000th part of the whole.

A compression of one part in 20,000 is caused by a pressure of 15·8 lbs. avoirdupois, or a depth of sea-water of 35,456 feet, or nearly 6000 fathoms. This result is confirmed both by the experiments of Mr. Canton and Mr. Perkins, and Mr. Johnson, and appears to be a perfectly safe basis for the compilation of tables of comparison and pressure. It is, however, highly desirable that the depths as thus determined, should be compared with those determined at the same time by soundings at different depths, as such would furnish the corrections, if any, necessary to be applied, and give confidence in the indications by the pressure gauge, and enable it to be used with confidence when strong currents render the use of the lead uncertain.

In observation, a small correction will be necessary to be applied on account of variation of temperature, and also for friction; this variation of volume is not uniform, being greater at high than at low temperatures. From many careful experiments made during the past year, it is found that 20,000 parts of boiled sea-water, at 86° Fah., contract to 19,945 at 70°, to 19,899 at 50°, and to 19,880 at 31°.

The following table shows the variation in the volume of sea-water, boiled to free it from air, with change of temperature:—

Thermometer 67·5° Fahr. Barometer, 29·92.

Degrees.	Number of parts.	Degrees.	Number of parts.
Fahr.		Fahr.	
86°	20000·0	53°	19905·0
85	19996·0	52	19903·0
84	19992·5	51	19901·0
83	19989·0	50	19899·0
82	19985·5	49	19897·0
81	19982·0	48	19895·0
80	19978·5	47	19894·0
79	19975·0	46	19892·5
78	19971·5	45	19891·0
77	19968·0	44	19890·0
76	19964·7	43	19889·0
75	19961·5	42	19888·0
74	19958·25	41	19886·7
73	19955·0	40	19885·5
72	19951·5	39	19884·5
71	19948·0	38	19883·5
70	19945·0	37	19883·0
69	19942·5	36	19882·5
68	19940·0	35	19882·0
67	19937·5	34	19881·5
66	19935·0	33	19881·0
65	19932·5	32	19880·5
64	19930·0	31	19880·0
63	19927·5	30	19880·0
62	19925·0	29	19880·0
61	19922·5	28*	19880·0
60	19920·0	27	19880·0
59	19917·5	26	19880·0
58	19915·0	25	19880·0
57	19913·0	24	19880·0
56	199.1·0	23	19880·0
55	19609·0	22	19880·0
54	19907·0		

* A gentle motion kept up to equalize the temperature of the sea-water has prevented its freezing at 28·5°.

Translated for the Journal of the Franklin Institute.

Morin on Resistance of Materials.

At the meeting of the French Academy of Sciences, 10th February, 1862, Gen. Morin made the following remarks:—

In presenting to the Academy this copy of the 3d edition of the work which I have published on the Resistance of Materials, I take the liberty of calling its attention particularly to two questions of considerable importance in this branch of science.

It is known that the fundamental hypothesis of the theory of the resistance of materials to the deformations which exterior forces tend to produce on them, consists in admitting that, within certain limits, determined pretty closely by experiment, the elongations and contrac-

tions experienced by the fibres, are proportional to the strains which produce them, and that within these same limits the fibres return exactly to their primitive dimensions so soon as the causes which have deformed them cease to act. It is then said that the elasticity is not changed.

But within the last few years, Mr. Eaton Hodgkinson, a learned Englishman, to whom we owe a great number of important researches upon these questions, has thought that he could deduce from his experiments that, when a body undergoes any elongation or contraction whatever, it never resumes exactly its former dimensions after the strains have ceased. Consequently, he admits, for example, that in the stretching of a metallic wire, there is always produced, in addition to the elastic elongation which ceases with the traction, a permanent elongation.

The discussion of the experiments of Mr. Hodgkinson, the examination of the arrangements which he had made for their execution, and the exceeding smallness of the permanent elongations observed, had led me to attribute these elongations, not to a deformation or variation in the length of the fibres themselves, but to a packing of the points of bearing and juncture, and the general straightening of the pieces under trial. This explanation appeared more probable to me, since the bars, of 15 metres total length, employed by Mr. Hodgkinson were made up of several pieces united by screws whose threads were in opposite directions, which under the action of the loads might well undergo packing.

To relieve the doubts upon this subject, it appeared to me necessary to make especial experiments, operating on metallic wires of a great length and of a single piece. For the execution of these experiments, I took advantage of the great height of the experiment-gallery of the *Conservatoire des Arts et Metiers*, and I could thus submit to traction copper and iron wires of over 22 to 24 metres in length.

By means of very precise cathetometers, the elongations produced between two marks traced on the wires, 21 metres apart, could be observed to a hundredth of a millimetre.

These experiments, however, presented a difficulty arising from the fact that the wires employed could only be found in commerce in the form of rolls of from 0·6 met. to 0·7 met. diameter, and that it was very difficult to straighten them completely before the experiment; so that they still presented slight bends, called *cosses* (kinks), the successive straightening of which under the action of the strains might and did exercise a certain influence on the results. But by repeating the experiments several times, this effect once produced ought to become less and less, and the true process of stretching ought to show itself better and better.

The weights suspended from the wires being added and removed successively, we could observe the elongation due to each one, and the return to the primitive length when they were removed, whence the values of the elastic and permanent elongations were deduced.

Now, while within extensive limits the first remained proportional

to the weights, as the theory requires; the others, which were always very small, went on diminishing from one experiment to another, in proportion as the wires were more completely straightened.

Thus, two copper wires, tried successively, gave the following results for the permanent elongation, measured in the fraction of the primitive length:—

No. 1. Diameter 2·584 mm., $\frac{1}{29,585}$, $\frac{1}{116,661}$, $\frac{1}{285,715}$;

No. 2. " 2·6 " $\frac{1}{15,000}$, 0, $\frac{1}{112,903}$;

quantities which may evidently be neglected when compared with the influence of the slightest change of temperature, since according to the results of La Place and Lavoisier, a difference of a single degree of the centigrade thermometer produces a change of length of $\frac{1}{58,400}$.

This last observation, indeed, explains how in the second experiment on wire No. 2, the permanent elongation might be 0, in consequence of a slight lowering of the temperature.

The examination of the co-efficient of elasticity deduced from these experiments, moreover, proves that in none of them was the elasticity changed. These co-efficients have the following values:—

No. 1. 6,909,971,309 kil.; 7,118,354,507 kil.; 6,521,770,186 kil.;
Mean, 6,850,003,001 kil.

No. 2. 7,310,170,535 kil.; 8,777,809,696 kil.; 7,374,366,197 kil.;
Mean, 7,827,448,809 kil.

General mean, 7,338,740,408 kil.

It will be observed that these values are all lower than those given by old experiments, which are for—

Drawn copper wire,	12,000,000,000 kil.
Annealed do.,	10,500,000,000 kil.
Mean,	11,250,000,000 kil.

It is, moreover, proper to observe that the densities of the wires anciently experimented on are greater than those of the wires now found in commerce, and that it appears to result from the comparison of the results of the old and new experiments, that, for the same metal, the elasticities vary in the same ratio with the density; which, moreover, appears rational.

Analogous experiments were performed on very fine iron wires of 0·2 mm. diameter; and by repeating the experiments three times in succession, the permanent elongations were found to be

$$\frac{1}{29,762}, \frac{1}{277,777}, \frac{1}{312,500},$$

whilst the elastic elongations remained very nearly the same, the co-

efficient of elasticity having the following values:—

19,326,210,980 kil.; 19,747,235,387 kil.; 19,857,029,388 kil.;

Mean, 19,643,458,585 kil.;

a value which differs very little from that deduced from the flexion of the best iron.

From the whole of these experiments, as well as from all those which I have had executed upon the flexion of bars of very great dimensions of cast iron, wrought iron, and steel, the proof appears to me to result, that the elongations and contractions pointed out by Mr. Hodgkinson could only be the effect of the packing, the partial compression of the junctures, or of the supports of the apparatus which he employed, and that the fundamental hypothesis of the theory of the resistance of materials, announced for the first time by the celebrated Hooke in 1670, in these terms, *ut tensio sic vis*, is in accordance with observation.

Another chapter to which I think it useful to call the attention of the Academy, is that which treats of axles and the tests to which they are subjected. By the discussion of these tests, and by the comparison of their results with the gradual variation of the co-efficient of elasticity in function of the elongations, I show that, in the regulation tests, the strains upon those fibres which have undergone the greatest elongations do not attain to the limit of rupture. On the other hand, I show by direct experiments that the straightening of axles which have been bent in these tests does not sensibly change their elasticity, provided it be properly done.

The general conclusions of this chapter are:—

1st, That the tests adopted by the artillery and the railroad companies, may, without danger of alteration, be undergone by good irons.

2d, That they separate the medium or bad irons.

3d, That, to compare them together, it is sufficient to limit the flexions so that the greatest elongations of the fibres shall be the same for all the axles.—*Comptes-Rendus*, 10 Feb., 1862.

Testing Armor Plates.

From the London Artizan, March, 1862.

The testing of the armor plates from the works of the Thames Iron Ship Company, the Atlas, at Sheffield; and the Lancefield, at Glasgow; were brought to a conclusion on the 14th ult. The plates as usual, were affixed to the sides of the *Java*, and the practice took place from the guns of the *Stork*, at 200 yards range. They were plates selected by the Government Inspector at each of the works from those manufactured in accordance with the right reserved by the Admiralty in their contract with the manufacturers. At this trial the "hammered plates" supplied by the Thames Iron Ship Building Co. proved to be so superior, that it will in all probability be the cause of the re-opening of the question, "Hammered *v.* Rolled" armor plates. 100-pounder Armstrong guns were used for the trial. The order of merit was as follows: Thames, 1; Brown, Rigby & Beardmore, 3.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

Experiments on Illumination with Mineral Oils.

By James C. Booth and Thos. H. Garrett.

On account of the abundant supply of petroleum or mineral oil, and its increasing consumption for illumination, we were induced to make some experiments in a practical way, for determining its illuminating power and economic value.

As in all such experiments, we also found the lack of a reliable standard of comparison, but as our object was purely practical, we employed Philadelphia city gas as our standard, because of its convenience, the tolerable accuracy of its measurement, and its sufficient uniformity of composition through the time required for each series of experiments. We measured the gas by a water-meter made for nice measurements, and which was kindly loaned to us by Dr. Charles M. Cresson. The gas-jet, a good fish-tail burner, was attached to the top of the meter, and was fixed at the uniform distance of six feet from the photometer. The distance of the lamp, &c., giving equal light to the gas-jet, was measured on the opposite side of the photometer. We may mention once for all, that, except in two cases expressly stated, all the flames were raised to their fullest height, just below the point of smoking.

We first ascertained that the results of experiments at a different flow of gas were not reducible to those of a uniform flow with any degree of accuracy with the burner we employed, and without a regulator, as indeed we might have concluded without experiment. The following table shows this:—

Table I.

No. of the experiment.	Flow of gas in cubic feet per hour.	Intensity of gas. / Intensity of lamp = 1.	Intensity of 2 and 3 calculated from 5·3 to 5·6 and 4·1.	Intensity of 2 and 3 calculated to that of 5·3 from the observed intensities at 5·6 and 4·1.
Lamp A. 1	5·3	1·5410	1·5410	1·5410
Lamp A. 2	5·6	1·6531	1·6283	1·5645
Lamp A. 3	4·1	1·3486	1·1650	1·7433
Lamp B. 1	5·3	1·8455	1·8455	1·8455
Lamp B. 2	5·6	2·0736	1·9848	1·9281
Lamp B. 3	4·1	1·6239	1·4277	2·0992

Although we found that, where the flow of gas differs only by ·1 or ·2 cub. ft. per hour, the calculated intensity approached to that deter-

mined by experiment, yet we concluded to present only the results of observation, as better for practical purposes.

We first determined the relative economy of several coal and mineral oils, and of burning fluid, at the request of Mr. Horace J. Smith, with the following results. The gas was flowing at the rate of 5·3 cub. feet per hour. The oils were burned in the same kind of lamps as in the subsequent experiments, and the burning fluid in the ordinary lamp used for it, with two divergent cylindrical wicks.

TABLE II.

NAME OF OIL.	Intensity of lamp. Gas = 1.	Gallons burned during flow of 1000 cub. ft. of gas.	Gallons giving equal light to 1000 cub. ft. of gas.	Relative amount burned. Best = 100.	Specific gravity of oil at 68° F.
Natrona, .	·6274	1·545	2·463	100	·7935
Portland, .	·6158	1·558	2·529	103	·8077
Lucifer, .	·6158	1·595	2·590	105	·7918
Lucesco, .	·5935	1·670	2·813	114	·7940
Burning fluid,	·1554	1·819	11·699	475	

As experiment thus proved that there was no great difference between the mineral oils, we selected one of them, "Lucifer Oil," and employed it in all subsequent experiments. In most of these, the common coal-oil lamp was used, with a flat wick of 0·7 inch breadth, by 0·08 inch thickness, and a hemispherical cap or deflector, with a lune or very elongated oval slit, through which the flame issues.

We ascertained that a perfectly straight cut of the wick yielded tolerably uniform results, differing but a few per cent. in relative economy, as the following shows:—

TABLE III.

No. of experiment.	Intensity. Gas = 1.	Gallons of oil burned giving equal light to 1000 cub. ft. of gas.	Relative amount for equal light.
1	·61579	2·78	100
2	·61579	2 80	101

These results were obtained at the same time with two lamps, but at different times and pressures of gas, they show an extreme variation that may amount to 15 per cent., chiefly due to the variation in our standard, burned from the same jet, at different pressures.

We then determined the influence of the shape of the top of the wick to ascertain the relative economy of care or carelessness in trimming the wick, with the following results. The 1st column in table IV. states the number of the experiment; the 2d gives the trim of the top of the wick; the 3d the shape of the flame; the 4th the in-

tensity of the light, compared to gas as unity; the 5th gallons of oil consumed during the flow of 1000 cub. ft. of gas, at the rate of 5·4 cub. ft. per hour; the 6th the gallons of oil that would be consumed to produce an equal light with 1000 cub. ft. of gas at the same rate of flow; the 7th the relative amount consumed for equal light, assuming the best at 100.

Table IV.

1.	2.	3.	4.	5.	6.	7.
No. of experiment.	Trim of wick.	Shape of flame.	Intensity of light of oil. Gas = 1·0.	Gallons of oil burned during flow of 1000 cub. ft. of gas.	Gallons of oil giving equal light to 1000 cub. ft. of gas.	Relative amount consumed for equal light.
1			·6267	1·614	2·576	100·0
2			·4727	1·345	2·846	110·5
3			·3906	1·125	2·880	111·8
4			·4259	1·247	2·929	113·7
5			·4171	1·223	2 932	113·8
6			·4082	1·199	2·936	114·0
7			·3735	1·150	3·078	119·5

A simple inspection of the 7th column shows that by any other method of trimming the wick than by a straight cut, No. 1, there is a loss of oil to obtain an equal amount of light, and that this loss may amount to from 10 to 20 per cent., where the wick is very badly

trimmed. The trim of wick was much exaggerated over what is likely to occur in practice, as shown in the 2d column, but in another experiment, in which the salient and retiring angles, as Nos. 3 and 7, were much more obtuse, the loss amounted to 4 per cent. in a trim like No. 3, and to 7½ per cent. in one like No. 7. In all our trials, the straight trim, No. 1, proved most economical, and that with a re-entering angle, No. 7, the worst. In giving a straight cut, threads of the woof are apt to project above the cut, or loose threads are allowed to remain on the wick. Their influence is shown in Nos. 5 and 6, and they may occasion a loss as high as 14 per cent. It frequently happens that in giving a straight trim, the two corners are apt to be left jagged, and to produce pointed and wasteful flames. We then tried the influence of cutting off these corners by a slight oblique cut after trimming straight. The loss was only 5 or 6 per cent., although our trim was much exaggerated. The best method of obtaining the fullest amount of light is to trim the wick straight across, and test the shape of the flame by lighting the lamp temporarily, and then, if necessary, to re-trim it until the shape approaches that of No. 1, presenting as even a top as practicable.

We determined the relative economy of a full and two-thirds sized flame in the same lamp, and that of two smaller lamps, with the results in table V. The columns are numbered, as in table IV., the trim of wick and shape of flame, columns 2 and 3, being omitted. In experiments 1 and 2, the same lamp was employed as before. In experiment 3, a similar but smaller sized lamp was used, with a wick 0·4 inch broad by 0·08 inch thick. In experiment 4, a small chamber lamp was used, with a cylindrical wick 0·15 inch diameter (like that of a common oil lamp), and a flat horizontal deflector, with a circular hole through which the flame issues. This flame is a very elongated cone of nearly 1½ inches height at its fullest without smoking, and ⅛ inch diameter. The flow of gas was 5·1 cub. ft. per hour.

Table V.

1.	4.	5.	6.	7.	
No. of experiment.	Intensity of light of oil. Gas = 1.	Gallons of oil burned during flow of 1000 cub. ft. of gas.	Gallons of oil giving equal light with 1000 cub. ft. of gas.	Relative amount burned for equal light.	Remarks.
1	·6158	1·709	2·776	100	Large lamp, full flame.
2	·4444	1·278	2·875	103	do. ⅔ full flame.
3	·3735	1·071	2 867	103	Smaller lamp, full flame.
4	·0772	0·345	4·475	161	Chamber lamp, full flame.

There appears to be little waste (only 3 per cent. for equal light) in burning a lamp at ⅔ the fullest height of the flame (compare Nos. 1 and 2); nor is there much difference (3 per cent.) between the larger

and smaller lamps, Nos. 1 and 4. Of course the chamber lamp, experiment 4, is not designed to give much light, and hence it appears to lose 60 per cent. in economy to obtain an equal amount of light from it. Its true economy consists in the very small quantity of oil consumed by it, with sufficient light for the purpose for which it is used, during the flow of 1000 cub. ft. of gas (at the rate of 5·1 cub. ft.), which is only one-third of a gallon. We shall revert to relative cost further on.

While making these experiments on the oils, we concluded to extend them a little further, in order to make a comparison of the oils with several kinds of candles in common use. The results are given in table VI., in which columns 1, 2, 4, 5, 6, and 7, correspond to the same of tables IV. and V., except that pounds a.d.p. are used instead of gallons (column 3, shape of flame, is omitted). Two candles were employed each experiment, but the results in columns 4 and 5 are reduced to the effect of one candle. This of course does not affect the quantities for equal light in columns 6 and 7. Paraffine candles were employed in experiments 1 and 2, spermaceti in 3 and 4, and adamantine in 5. In experiments 1, 3, and 5, the wicks were arranged so as to burn the material to the best advantage, but in 2 one of the paraffine wicks, and in 4 both of the sperm wicks, were only slightly curved, and had small beads of snuff on their tips, as shown in column 2. The rate of gas is 5·1 cub. ft. per hour.

Table VI.

1.	2.	4.	5.	6.	7.
No. of experiment.	Shape of wick.	Intensity of one candle. Gas = 1.	lbs. of candles burned during flow of 1000 cub. ft. of gas.	lbs. of candles giving equal light to 1000 cub. ft. of gas.	Relative amount burned for equal light.
1		·1019	3·507	34·42	100
2		·0957	3·507	36·64	106
3		·1050	3·912	37·25	108
4		·0868	3·912	45·07	131
5		·1080	5·098	47·18	137

A comparison of the results in column 7, compared with the shape of wicks in column 2, shows the importance of not permitting beads of snuff to accumulate on the ends of the wick. To obviate it, it is only necessary to keep the wick bent nearly at right angles, as shown

in experiments 1, 3, and 5, in column 2, so that the air will keep the wick *snuffed*, by burning off the extremity.

It is hardly fair to compare candles and gas for equal light, as in column 6 of table VI., because the former are rarely employed for illuminating a large space, to which gas is peculiarly well adapted. If we compare the result of two candles, which give a fair amount of light for reading and work near them, we have only to double the figures given in col. 4 for intensity, and in col. 5 for the quantity used in the same time as 1000 cub. ft. of gas flowing at the rate of 5·1 cub. ft. per hour. This quantity would be 7 lbs. for paraffine, 7¾ lbs. for spermaceti, and 10 lbs. for adamantine candles.

If we now make a comparison of the relative cost of gas and mineral oils, we shall first suppose them employed for illuminating a large space. In this case, we can only compare them with reference to an equal amount of light. When burning to fair advantage, it appears from table III., experiments 1 to 4, and tables IV. and V., experiment 1, that 2½ to 2¾ gallons of oil give equal light with 1000 cub. ft. of gas. To these we will add by way of contrast, the best results with candles in table VI., experiments 1, 3, and 5. We have added a column for cost of 1000 cub. ft. of gas, of one gallon of oil, and of a pound of candles, and finally the column of expense for equal light.

TABLE VII.

Name of Material.		Quantity for an equal amount of light.	Price of unit of quantity.	Cost of quantity for equal light.
Gas, . .		1000 cub. ft.	$2 25 per 1000 c.f.	$2 25
Petroleum,		2⅜ galls.	0·45 " gall.	1 07
Candles.	Spermaceti, .	37 lbs.	0·50 " lb.	18 50
	Paraffine,	36½ "	0·32 "	11 68
	Adamantine,	47 "	0·25 "	11·75

It will be observed that we have taken fair retail prices. It is hardly worth while to call attention to the extravagance of employing candles for illumination. It is more to our purpose to compare gas and mineral oil. Even allowing the price of gas to be reduced, we find that it costs twice as much as mineral oils for producing equal light. A moment's consideration, however, will show that, for all ordinary uses, the comparison for an equal amount of light is an unfair one for the oil. Gas-lights are fixed, or at best can be moved by a swing-joint or drop-light within a very limited space; so that any work to be done must, however inconvenient, either be carried near to the jet, or we must employ a larger amount of gas, proportioned to the *square* of the distance, *i. e.*, at twice a given distance, four times as much gas is required for an equal effect, &c. On the other hand, the lamp can be moved to any position most convenient for work, with this increased benefit, that the intensity of its light is inversely as the square of the distance.

It is because of the fixedness of gas-light, and the movability of the

lamp, that so much less of the oil is required to obtain an equal advantage of light, and the amount of oil burned in the common coal oil lamp, as employed in our experiments, in the *same time* as 1000 cub. ft., expresses more correctly their relative economy. As two candles are usually burned for the same purpose, we insert their results also in the following table. Further, as the smaller lamp, table V., experiment 3, is considered as affording ample light by many persons for reading, sewing, &c., we have included it. Lastly, the small chamber lamp, table V., experiment 4, is included so that persons may compare its cost with that of the wax taper floating on oil, or any other night-light. In order to make a fairer comparison of cost, the price of gas is assumed at $2 10 per 1000 cub. ft.

TABLE VIII.

Name of Material burned.	Material — how burned.	Quantity burned in same time as 1000 cub. ft. of gas.	Relative cost of material burning in equal time.	Cost for an average winter evening of 5 hours.
Philada. Gas,	5·1 cub. ft. pr hour.	1000 cub. ft.	$2·10	5¼ cents.
Petroleum,	Large lamp.	1⅞ galls.	0 73	1¾ "
do.,	Smaller do.	1 "	0 45	1 1-7 "
do.,	Chamber do.	¼ "	0 15	⅜ "
Spermaceti,	Two candles.	7¼ lbs.	3 87	9⅔ "
Paraffine,	do.	7 "	2·24	5·7 "
Adamantine,	do.	10 "	2 25	5⅝ "

A small chamber-lamp is usually burned through the whole night, say for 10 hours. In this case it costs three-fourths of a cent per night. But let it be observed that at this rate of cost it gives three-fourths as much light as a sperm, paraffine, or adamantine candle, as shown by comparing its intensity, No. 4, table V., with those of experiments 1, 3, and 5, table VI. To ascertain the lowest limit of cost of this little lamp, we tried its consumption of oil with a very low flame, rising about one-tenth of an inch above the deflector, its light (not measured) appearing to be somewhat less than that of the common night taper. In this case, its expense would be a little more than one-fourth of a cent for ten hours. But, at this low limit, combustion is not perfect, and a disagreeable odor arises from it. When burned at ⅓ to ½ its fullest height, it emits no odor, and then costs a little more than one-third of a cent for ten hours.

In this essay we have only taken into consideration the relative economy of mineral oils as sources of light, compared with gas and candles, in which respect the last column in table VII., and especially the 4th column in table VIII., show most convincingly that the oils will force themselves more and more into notice and use, and to a moderate extent will displace the use of gas and candles.

It would, however, be a partial and, perhaps, culpable view of the subject, if we were to omit a notice of danger in the use of the mineral oils, whether obtained from coal or petroleum. We have not made any direct experiments on this point, but we are bound to admit the

result of experience in the use of the oils. Although they are far less explosive than burning fluid, or any alcoholic solution of a hydro-carbon, they are by no means free from liability to explosion. The danger arises from the presence of benzole (benzine), and other volatile hydro-carbons, which have not been expelled in the process of refining, and we shall probably be subjected to this danger some time longer, in consequence of the want of skill which knows not how to remove the volatile fluids, or by reason of manufacturing cupidity, which would prefer allowing them to remain in the oil, in order to increase the quantity sold. We think there is ground for asserting that the mineral oils *can be made* as free from danger as spermaceti or lard oil. One great desideratum is a means of determining the freedom from danger by a simple apparatus, easily and inexpensively worked. Until the character of large dealers shall have been established for the sale of oil free from danger, we will content ourselves with this general advice to those who use the oils: never to fill a lamp at night, and not to store the oil where it can become heated.

It is not to be apprehended in the slightest degree that the oils will supersede the use of gas, especially in cities and towns, nor even in many country houses. Saving of labor, convenience, and greater safety, will cause gas still to dominate over all other sources of illumination. Besides, the astonishing cheapness of the natural mineral oils, and their richness in illuminating hydro-carbons, will probably oblige gas companies to consider the advisability of mixing mineral oil gas with coal gas. The illuminating power of any coal gas we have seen may be greatly increased with advantage, and the consequent liability to smoke may be obviated by diminishing the size or improving the form of the jet or burner.

Would the growl of the public be heard against a change of burners if they were to receive due notice that on and after a certain date, if they were to change all their burners to one-half the present size, they would get the same amount of light as they now do, without any more smoke, and at one-half the present cost? especially when they are informed that the whole cost of the change will be defrayed by the saving of the first six months or a year? We leave it to gas companies to resolve this question or its alternative, whether the extraordinary comparative cheapness of mineral oil illumination will not stimulate invention to contrive ways of burning the oil, or of making gas from it in a small way, so as to obviate every objection to its use, and so to supersede the use of company-made gas.

Letter from Prof. KIRCHHOFF *on the Chemical Analysis of the Solar Atmosphere.*

From the Lond. Edin. and Dub. Phil. Mag., March, 1861.

Since I sent in my last report to the Berlin Academy, I have been almost uninterruptedly engaged in following out the investigation in the direction I there indicated. I will not now speak either of the

theoretical proof I have given,* of the facts I there announced, or of the experiments by help of which Bunsen and I† have shown that the bright bands in the spectrum of a flame serve as the surest indications of the metals present therein; I will take the liberty, in this communication, of informing you of the progress I have made in the chemical analysis of the solar atmosphere.

The sun possesses an incandescent, gaseous atmosphere, which surrounds a solid nucleus having a still higher temperature. If we could see the spectrum of the solar atmosphere, we should see in it the bright bands characteristic of the metals contained in the atmosphere, and from the presence of these lines should infer that of these various metals. The more intense luminosity of the sun's solid body, however, does not permit the spectrum of its atmosphere to appear; it *reverses* it, according to the proposition I have announced; so that, instead of the bright lines which the spectrum of the atmosphere by itself would show, dark lines are produced. Thus we do not see the spectrum of the solar atmosphere, but we see a negative image of it. This, however, serves equally well to determine with certainty the presence of those metals which occur in the sun's atmosphere. For this purpose, we only require to possess an accurate knowledge of the solar spectrum, and of the spectra of the various metals.

I have been fortunate enough to obtain possession of an apparatus from the optical and astronomical manufactory of Steinheil in Munich, which enables me to examine these spectra with a degree of accuracy and purity which has certainly never before been reached. The main part of the instrument consists of four large flint-glass prisms, and two telescopes of the most consummate workmanship. By their aid, the solar spectrum is seen to contain thousands of lines; but they differ so remarkably in breadth and tone, and the variety of their grouping is so great, that no difficulty is experienced in recognising and remembering the various details. I intend to make a map of the sun's spectrum as I see it in my instrument, and I have already accompanied this for the brightest portion of the spectrum—that portion, namely, included between Fraunhofer's lines F and D. By painting the lines of various degrees of shade and of breadth, I have succeeded in producing a drawing which represents the solar spectrum so closely, that, on comparison, one glance suffices to show the corresponding lines.

The apparatus shows the spectrum of an artificial source of light, provided it possess sufficient intensity, with as great a degree of accuracy as the solar spectrum. A common colorless gas-flame in which a metallic salt volatilizes, is in general not sufficiently luminous; but the electric spark gives with great splendor the spectrum of the metal of which the electrodes are composed. A large Ruhmkorff's induction apparatus produces such a rapid succession of sparks, that the spectra of the metals may be thus examined with as great facility as the solar spectrum.

By means of a very simple arrangement, the spectra of two sources

* Phil. Mag., July, 1860. † Ibid. August, 1860.

of light may be compared. The rays from one source of light can be led through *one* half of the vertical slit, whilst those from another source are led through the *other* half. If this is done, the two spectra are seen directly under one another, separated only by an almost invisible dark line. By this arrangement, it is extremely easy to see whether any coincident lines occur in the two spectra.

I have in this way assured myself that all the bright lines characteristic of iron correspond to dark lines in the solar spectrum. In that portion of the solar spectrum which I have examined (between the lines D and F), I have had occasion to remark about seventy particularly brilliant lines as caused by the presence of iron in the solar atmosphere. Angström only observed three bright lines in this part of the spectrum of the electric spark; Masson noticed only a few more; Van der Willigen says that iron produces only a very few feeble lines in the spectrum of the electric spark. From the number of these lines which I have been able to observe with ease and map with absolute certainty, some idea may be formed of the capabilities of the instrument which I am fortunate enough to possess.

Iron is remarkable on account of the number of the lines which it causes in the solar spectrum; magnesium is interesting because it produces the group of Fraunhofer's lines which are most readily seen in the sun's spectrum, namely, the group in the green, consisting of three very intense lines, to which Fraunhofer gave the name *b*. Less striking but still quite distinctly visible are the dark solar lines coincident with the bright lines of chromium and nickel. The occurrence of *these* substances in the sun may therefore be regarded as certain. Many metals, however, appear to be absent; for although silver, copper, zinc, aluminium, cobalt, and antimony, possess very characteristic spectra, still these do not coincide with any (or at least with any distinct) dark lines of the solar spectrum. I hope before long to be in a position to publish more extended information on this point.

The combination of Ruhmkorff's induction coil with the spectrum apparatus will doubtless also be of importance for the chemistry of terrestrial matter. Very many metallic compounds do not give the spectrum peculiar to the metal when placed in a flame, because they are not sufficiently volatile, but they give it at once when placed on the electrodes of an electric spark. These lines are then indeed seen, together with those of the metal of the electrode, and those of the air through which the spark passes; and owing to the great number of bright lines which compose the spectrum of every electric spark, it would be almost impossible, without a special arrangement, to distinguish the lines caused by the metal of the electrodes from those produced by the metallic salt added. The special arrangement which in this case removes all difficulty, consists in allowing the spark to pass at the same instant between two pairs of electrodes, in such a manner that the light of one spark passes through the upper half of the slit, whilst the light of the other spark passes through the lower half of the slit, so that the two spectra are seen one directly above the other. If both pair of electrodes are pure, both the spectra are

alike; if a metallic salt is brought on to one of the electrodes, the lines peculiar to that metal appear in the one spectrum in addition to those present before. These are recognised at the first moment, because they are absent in the other spectrum. The lines which are common to the two spectra may serve, when they are once for all drawn, as the simplest mode by which to represent the position of the lines of the other metals employed.

I have proved that in this way the metals of the rare earths, yttrium, erbium, terbium, &c., may be detected in the most certain and expeditious manner. Hence we may expect that, by help of Ruhmkorff's coil, the spectrum-analytical method may be extended to the detection of the presence of all the metals. I trust that this expectation may be borne out in the continuation of the research which Bunsen and I are jointly carrying on with the object of rendering this method practically applicable.

Waterproof Glue.

From the Lond. Chemical News, No. 41.

Fine shreds of india rubber, dissolved in warm copal varnish, make a waterproof cement for wood and leather. Take glue, 12 ounces, and water sufficient to dissolve it; then add 3 ounces of resin, and melt them together, after which add 4 parts of turpentine. This should be done in a water bath, or in a carpenter's glue-pot. This also makes a very good waterproof glue.

Lock Controversy.

From the Journal of the Society of Arts, No. 476.

Steps are being taken in Wolverhampton which are likely to revive the great lock controversy of ten years ago. There is now in course of manufacture in that town a new patent keyless lock, having 244,140,125 combinations, to open all of which would take a man—supposing he could live so long—some 130 years! This extraordinary lock, which is based upon the permutation principle, is the invention of Viscount de Kersolon, of Paris, and by him communicated to Mr. Edward Loysel, of Cannon street, London, who is better known as the patentee of the coffee percolator. Although it is termed a keyless lock, it has as many keys as there are combinations, the back parts being the locks, and the front parts the keys, which cannot be removed. Every change made in the concentric rings answers the same purpose as the keys, so that a lock which has seven permutations, or 5040 combinations, has 5040 keys, and so it is termed a keyless lock, with 5040 or any number of keys. The specimen has six concentric cylinders, upon the projecting or outer edges of which are twenty-five of the twenty-six letters of the alphabet, and it is only when these letters are brought into a certain predetermined arrangement that the other parts of the lock can be so worked as to admit of the bolt being

drawn for the purpose of shutting or opening the article to which the lock is applied. It is absolutely necessary, as in the old letter padlock, to know the proper arrangement or combination of letters before the lock can be opened. In order to prevent the particular combination of letters from being discovered by feeling the parts, as is sometimes the case, the inner edges of the movable concentric cylinders are toothed or serrated, so as to deceive any person who may attempt to tamper with the lock. In the event of the particular combination of letters not being discovered by the person desirous of opening the lock, the exhausting of all the variations which are in that case necessary to the success of the operation would entail an expenditure of the time we have mentioned, supposing the operator to make ten changes a minute, and to manipulate ten hours on every working day. It is intended to place these locks on some iron safes which are also being made in Wolverhampton for exhibition at the forthcoming "World's Fair." In one of the safes it is proposed to place the sum of £500, which is to fall to the lot of the person who may be fortunate enough to effect an opening into the safe.

The production of the lock for the market is in the hands of Mr. Aubin, the inventor of the "Trophy lock of ingenuity," which was exhibited in the Hyde Park Palace, and subsequently purchased by Mr. Hobbs. Mr. Aubin, then a working locksmith, is now the proprietor of works in Wolverhampton, where he employs machinery invented by himself, and of equal delicacy with that displayed in the model which made his name celebrated. His ingenuity is being further displayed in the designing and constructing of machinery adapted to the manufacture just described. Mr. Aubin's practical experience also is being brought to bear in making such improvements upon the Count's lock as are required to increase the probability of its success in a financial aspect. The principle of the lock may be applied to every variety of this description of fastening, and when used upon a traveling bag is a vast improvement upon locks that require keys to open them, and is at the same time a great ornament.

New Substitute for Silver.

M. Traluc, of Nismes, has recently proposed as a substitute for silver for various uses, a white alloy which has the property of resisting vegetable acids. It is formed of 375 parts of Banca tin; 55 nickel; 50 regulus of antimony; 20 bismuth. One-third of the tin is put in a crucible of the proper dimensions with the nickel, antimony, and bismuth; upon this first layer is put another third of the tin, and then a thickness of an inch and a half of wood-charcoal; the crucible is then to be covered and brought to a white-heat; by means of an iron rod also heated to redness it must be ascertained that the nickel is fused, and the antimony reduced; the remainder of the tin is then introduced through the charcoal, and the mass stirred until the metals are thoroughly combined; it may then be cast in ingots or otherwise.

Cosmos.

On the Construction of Iron Ships of Great Length. By WILLIAM FAIRBAIRN, Esq., LL.D., F.R.S., &c.

From the London Mechanics' Magazine, November, 1860.

In a previous lecture I endeavored to inculcate principles on which iron ships ought to be built, in order to secure perfect safety, and to give to the public increased confidence in the stability of these constructions. In pointing out how these desiderata may be obtained, I confined my attention to vessels varying from 500 to 1500 tons burthen, and not exceeding 300 feet in length and 41 feet 6 inches beam. In these constructions I attempted to prove that the present system was defective, and that in certain positions a vessel built upon this principle must, of necessity, break up and go to pieces. These views were not founded upon theoretical speculations, but upon experimental facts; and to which I considered it my duty to direct public attention.

It cannot be denied that the most disastrous effects have followed from these defects; and it appears imperative, for the sake of life and property, that a new and more perfect system of construction should be adopted, founded on definite laws by which the resisting powers of materials in different forms and conditions are governed. As respects iron, nearly the whole of these laws are known; and we are at no loss to discover its ultimate powers of resistance in whatever position it is placed, or to proportion its dimensions to meet with safety the forces to which it is subjected. Possessing this knowledge, and having it in our power to apply it, why should we neglect its application in structures of such vast importance as those in which our lives and fortunes are so often embarked? The surveyors of Lloyds, most excellent, well meaning, gentlemanly men as they are, may say what they please; but I have no hesitation in stating that their regulations are very defective and require immediate revision, and such a revision in my opinion should be based upon principles of exact science, and calculated to secure a maximum strength in the iron ship. I do not wish to find fault, nor do I assert that the alterations I have to propose are in any sense the best calculated to produce a maximum effect; on the contrary, they may require correction in practical details. But this I believe, that the present build of ships is decidedly imperfect, and admits of great improvement, both as regards security and economy in the use of the material of which they are composed.

The cellular system has been objected to on the ground of the inconvenience of longitudinal stringers along the deck on each side of the hatchways, and their liability to oxidation. Now, so far as regards the deck, these objections have in reality no weight, for the proposed cellular stringers need not exceed fifteen inches square, or eighteen inches wide by fifteen deep; and these, with the cells which form part of the bulwarks, will afford all that is wanted to give the required stability to that part, forming, if properly put together, perfectly rigid horizontal columns to resist the force of compression on the one hand, and tension on the other. Again, as regards oxidation, none can occur to any injurious extent so long as these cellular stringers are below deck and are riveted water-tight, which may be done with perfect

safety and without diminution of their strength. From these remarks, and from previous statements, it will be seen that the excess of material is not required in the vicinity of the neutral axis, where the strain is least, but at the extreme top and bottom, where the strains are most severe when the vessel is pitching in a heavy sea.

It is a universal law of construction that the resistance provided for should be proportional to the assailant force in each part, and in order to effect security it should be always greatly in excess. In building a ship, as in other similar structures, the first thing is to ascertain the points of greatest strain, and to provide at those parts the greatest power of resistance; but to build a ship with equal thicknesses of plates throughout, or any other vessel liable to be ruptured by forces that act with double the intensity in some parts that they do in others, is not only a great waste of valuable material, but is absolutely injurious in so far as it adds by increased weight to the destructive element that tends to break up the vessel. This being the case, how essentially necessary is it that the strengths should be carefully proportioned to the strains, and the material arranged in such a form as to offer a harmonious resistance to the forces thus acting upon it.

To effect this distribution, the object of the previous investigation, and keeping in view the same principles I there ventured to advocate, I now come to a larger class of vessels, which involve at the present time considerations of vast importance to the owners and builders and others interested in the extension of commerce. To these vessels I would now venture to apply the same principles, so as, in my opinion, to secure the necessary strength under the varied forms and circumstances to which they are subjected.

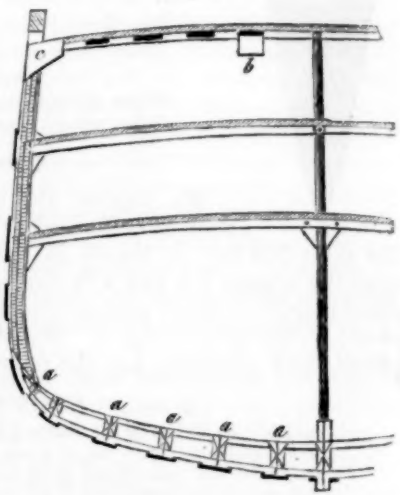
We do not know what changes are in store for us as a result of the performance of the Great Eastern; that vessel has not yet been fully tried, and it would be premature to anticipate results; as it is, we can only assume that she will prove commercially successful, and although probably not to the extent expected by her more sanguine advocates, yet that she may possess qualities favorable to a considerable increase in the dimensions of our vessels, both in relation to their capacity for cargo, speed, and other good properties. If we assume this as the result of the forthcoming performances of the Great Eastern, we may take as the basis of our inquiry a vessel of 500 feet length between the perpendiculars and 68 feet beam. The question for consideration then is, on what principle should she be built for the purpose of attaining the greatest security with the least material? To answer this inquiry we may consider—

1. The general principle of construction.
2. The frames and ribs, and their distribution as affecting the transverse strength.
3. The plating or sheathing, including stringers, cells, &c., as affecting the longitudinal resistance to fracture.
4. The decks, bulkheads, and internal fittings.
5. The bows and stern in their resistance to concussion.
6. The resisting powers, durability, and economy of the ship taken *en masse*.

In our attempts to apply sound principles in construction, we have two things to determine:—first, the properties of the material we have to deal with, and second, the forms and conditions in which it should be applied. In regard to the former, it is essential to sound construction that we should have good material, and on this point it will be requisite to offer a few suggestions. To those acquainted with the iron trade, it is well known that we have five or six different sorts of plate and bar iron, namely, cinder plates, common plates, best plates, double wrought plates, and the superlatively good best-best plates. The same varieties may be had in bars, and it requires no small degree of skill and penetration to determine from appearance what is good and what is bad. One thing is, however, evident, that no description of plates or angle iron should be employed in ship-building that would not stand a test of 20 to 24 tons tensile strain per square inch. That these plates should be made from good puddled bars, piled and rolled at the proper heat, is also essential to durability and security in naval construction; and the additional cost of 20s. per ton should not be an object when compared with the superior quality of the iron employed. In fact, it is a mistaken economy to suppose that a reduced rate per ton in the first cost of an iron ship is an advantage. On the contrary, it involves in reality a serious loss; the inferior material can never be depended upon, and the risk incurred in consequence is too great to lend to its employment any countenance or support. On the other hand, when a better quality of iron is used, less weight is required, and the builder executes his work with greater exactitude and with less risk of injury to the material.

Assuming that the material is unexceptional as to quality, we have next to consider the principle on which large vessels, 500 ft. in length, should be constructed for the purpose of obtaining the maximum of strength with the least material. In this case it will be necessary to depart from the ordinary rules of construction, and instead of a closely packed series of transverse frames, it will be important to place the principal frames at distances of 4 feet apart, using the remainder of the material in the shape of longitudinal keelsons or stringers, as shown at *a a*, fig. 1.

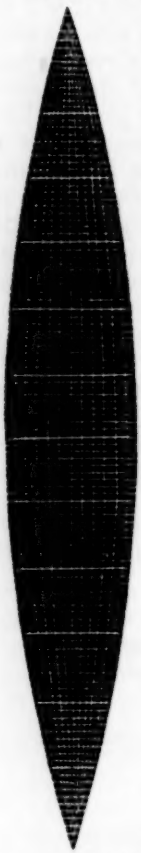
Fig. 1.



Framing the hull of the ship in this form gives greatly increased stability, and in a vessel of this magnitude the whole of the material in her hull will be arranged in parallelograms, measuring at midships 6 feet by 4 feet, and narrowing

as they approach the stem and stern until the lines of the vessel bring them in contact, at which point two cells would run into one till the extreme points were reached at each end. If we remove the iron sheeting, the bottom of the ship will present a large honey-combed surface, as in fig. 2. Now of all forms this is the strongest, and a large vessel constructed in this way would have immense rigidity, and form one continued line of walls or girders, greatly in favor of the material, and adding much to the strength of the ship. Besides, in the above form the plates forming the keelsons and frames may be much reduced in thickness, and two-thirds of the transverse frames being dispensed with, we can afford to increase the number of longitudinal keelsons without increasing the weight of the material in the ship.

Fig. 2.



For comparison, let us estimate the strength upon this construction and that on the plan of frames 18 ins. apart, with only three longitudinal keelsons in the bottom. In the proposed improvement there are thirteen longitudinal keelsons, and these, with the outer and inner sheathing at the bottom, cellular deck, &c., would probably give a displacement of 4500 tons.

AREA OF BOTTOM.

	Ft.	Ft.	In.		Sq. ins.
1. Centre keelson	500	× 6	× ¾	and angle iron	72
2. Keelsons	"	4	× ⅝	"	90
4. "	"	3½	× ½	"	132
2. "	"	3	× ½	"	60
2. "	"	2½	× ½	"	54
2. "	"	2	× ½	"	48
Total keelson area,					456
80 feet of sheathing plates averaging ¾ in. thick,					720
60 feet interior sheathing averaging ⅜ inch,					270
Total area of bottom,					1446

We suppose the upper part of the ship along the deck to be formed on the same principle as advocated for ships 300 feet in length in the previous lecture, with two cells near the centre, *b b*, and with two square and two triangular longitudinal cells, *c c*, at the side, extending the whole length of the ship, as shown in the section, fig. 1. We should then have with the stringer plates, deck planking, &c., the following sectional area:—

AREA OF THE TOP.

2 middle cells 20 ins. × 20 ins. × ¾ ins.	120	sq. ins.
2 side cells 30 ins. × 18 ins. × ¾ ins,	142	"
2 triangular side cells 36 ins. × 36 ins. × ¾ ins.	162	"
Angle iron to the above,	138	"
16 feet of plates on sides = 192 ins. × ¾ in.	144	"
Deck stringers 360 ins. × 1 in.	360	"
Deck planking, say	300	"
Total area of top,	1366	"

This gives an excess of 140 sq. ins. in favor of the bottom as a compensation for extra wear and tear on that part.

The strength of a vessel built in this form with the above sectional areas, and properly constructed to resist a lateral strain, may be found as before by applying the formula, $W = \frac{a\,d\,c}{l}$. With the constant 60 as before, and taking the smaller or deck area—

$$a = 1366 \qquad c = 60$$
$$d = 40 \qquad l = 500$$
$$W = \frac{1366 \times 40 \times 60}{500} = 6556{\cdot}8 \text{ tons},$$

the breaking weight at the centre, or 13,113·6 tons with the load distributed. Again, comparing this with the weight of the ship and cargo, and taking her loaded draft at 24 feet, we have a displacement of about 9800 tons, which, it will be observed, leaves a margin of strength of 3313 tons, sufficient for all practical purposes as regards the durability and safety of the ship.

We could multiply these calculations to any extent, but I only wish to point out for the guidance of engineers what we consider the best and most effective principle of construction to insure a powerful resistance to strain, and a distribution of material capable of withstanding the shocks of a rolling sea, or any other trials to which in extreme cases the vessel might be exposed.

Water-tight bulkheads are of great importance in the class of vessels we are now considering. These not only bind the sides of the ships together from the keel to the deck, but they give rigidity and strength to the whole structure, and there is no part more deserving of attention in large ships than these bulkheads. In a ship of 500 ft. length and 68 feet beam, it might be desirable to divide her into two parts by a longitudinal bulkhead up to the middle deck. That would, however, be inconvenient in many cases in both sailing vessels and steamers. In fact, in the latter it would be inadmissible on account of her machinery; we must, therefore, deal with the construction under those conditions required by the service for which she is intended. This does not, however, affect the general principle that bulkheads made perfectly water-tight and stiffened with angle and T-iron should form component parts of the structure, and require great attention both as to the number of compartments and the position in which they are placed.

It now remains for consideration in detail whether the principle of longitudinal keelsons, with corresponding plate and cellular stringers, is or is not superior to the ordinary construction with transverse frames. In vessels of such immense tonnage it would appear from the formula applied to hollow girders that a great increase of transverse strength may be gained, as in the case of smaller vessels, previously considered. In a vessel floating on water the force of external pressure at a depth of 24 feet is about 1572 lbs. per square foot, or 11 lbs. per square inch, and this distributed over the surface of one of the

cells, 6 feet by 4 feet, amounts to 17 tons nearly, or is equivalent to a force of 8½ tons at the centre of the cell at midships. Now this would be too great a pressure for a ¾-inch plate, and would cause a bulging inwards were it not for the counterpoising pressure on the adjoining cells, which has a tendency to neutralize the bulging tendency by straining the metal uniformly over the keelsons and transverse ribs. In order, however, to increase the rigidity of these parts, it will probably be necessary to run down the middle of each cell bars of T-iron, 6 inches by 5 inches, as shown at *g*, fig. 3, in the line of the keelsons, *b b*, composed of angle irons and vertical plates riveted to the sheathing plates 3 ft. wide and 12 ft. long. On this principle the T-iron would also rest upon the longitudinal plates, and the transverse joints would be covered by the plates shown at *c c*, fig. 4, placed under the frames and chain-riveted. The covering plate in this case being thicker than the sheathing plates, in order to compensate for an increased number of perforations for rivets along the line of the joint.

Fig. 3.

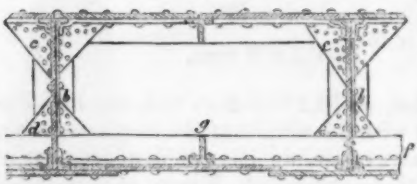
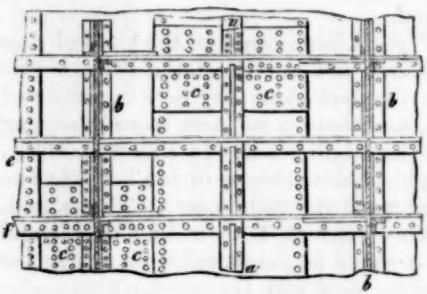


Fig. 4.



It has been stated that it would be necessary to have an increased number of transverse frames, in order to bring the lines of the vessel into shape; should this prove correct, another light rib may be used, as shown at *e e* in the plan, fig. 4, riveted to the sheathing on the same principle as the other ribs, *f f f f*, which are 4 feet asunder. These practical details, however, we may leave to the judgment of the builder, as not essential to the stability of the ship. In this way the resistance of the cells to bulging would be more than doubled, and the whole of the cellular construction rendered secure under every form and condition of strain. The preceding sketch (fig. 3) represents the sectional form of the cells, each of which may be stiffened by gussets, *a a* and *d d*, riveted to the angle iron of the keelsons and transverse frames. Fig. 4 shows in plan the keelsons, *b b*, ribs, *f f*, additional rib, *e e*, T-iron along the bottom, *a a*, and covering plates, *c c*, chain-riveted. On this plan the cells would be open from one bulkhead to the other, and with proper water-tight manholes between each bulkhead might, if necessary, be used for stowage or for the insertion of tanks in which fresh water might be kept ready for use.

On the above construction the sheathing plates would be lap-jointed, using the keelson angle irons and the intermediate T-irons as stiffen-

ers for the cells, as shown in fig. 5, which represents one-half of the cellular system at the bottom of a vessel from the keel to the turn of the bilge.

Enlarged covering plates, chain-riveted for the transverse joints, are of great importance both in regard to the lateral and longitudinal strength of the ship. The resistance to tension would be one-sixth greater than with the ordinary construction, and thus the security of the ship would be greatly increased.

Fig. 5.

As regards the upper and intermediate decks, there would be no change except the introduction of two cells, one on each side of the hatchways, and four other cells, two on each side of the ship, as shown in fig. 1. In the sectional area of the upper deck it will be observed, that in the previous calculation we allowed about one-sixth as the value of the deck planking in resisting a compressive or tensile strain, and that we made a further allowance of material to the bottom to compensate for the wear and tear of those parts. Hence, the sectional area of iron in the upper deck will be to that in the bottom in the ratio of 4 to 6. These proportions have been assumed, but they are in accordance with experimental researches, or at least so far as we have results bearing on this question; and it only requires an extension of such experimental investigations to prove how far these proportions approximate to the correct ratio for resisting the strains at those parts respectively.

A series of well-conducted experiments of this kind is much wanted, and a Government grant of £1000, with a similar grant from Lloyds and from the shipowners fund, would set the question at rest, and establish in shipbuilding, as in other constructions, true principles, the correct expression of physical laws. It is with the object of aiding in the attainment of this that I have ventured to make these suggestions. The subject is one of deep importance to the community, one on which we are very deficient in knowledge, and one which will reward investigation, and that with great benefit to the public and to mechanical science, and without injury to existing interests.

Impressed with the conviction that we are still laboring under difficulties from a want of knowledge of the true principles of naval construction, we are encouraged from other movements in looking forward to the time when these difficulties will be removed, and when greater economy in the distribution of the material will be accomplished from the reduction of the whole system of shipbuilding to the exact laws of science.

In the discussion of this question I have not ventured to inquire into the applicability of the cellular construction to ships of war, and my reason for the omission has been that the effect of shot upon iron ships has yet to be decided upon. I am aware that the Admiralty some years since came to a conclusion adverse to the use of iron, which

I am not now prepared to call in question. But the improved condition of our iron constructions, and the increased tenacity of the material, taken in connexion with our improved system of gunnery, may afford reasons for altering that decision, and lead to results favorable to the use of iron as a material for building vessels of war.

With the Whitworth rifled gun, for example, with an oblong flat-ended missile, iron is penetrated by a process that drills or cuts out the core without splintering or tearing up the surrounding surface; and looking forward to still further improvements, the iron ship may be increased with safety under the influence of a more destructive arm than has heretofore been used. Be this as it may, the same principles of construction will apply to the navy as to the vessels of the merchant service; and till it has been more conclusively proved that iron is inapplicable to the construction of ships for the purposes of war, we may reasonably conclude that this material may ultimately become the best safeguard of Her Majesty's dominions at home and abroad.

Destructive Action of Minium on the Hulls of Iron Ships. Letter from M. JOUVIN to M. DUMAS.

From the London Chemical News, No. 86.

The observations I made last March on the iron hull of the Imperial packet *Guienne*, are confirmed in every point by those furnished by the hull of the packet *Le Bearn*. At first sight there was such strong resemblance between the state of the two hulls, that they seemed identical; but by going into details, the following differences were observed:—

The whole of the hull of *Le Bearn*, which has received a coating of minium, has become dull red; the vivid tint of oxide of lead is extinguished in a vague color, as if washed out, or as if the painting had been covered with a sort of grey glazing. On this ground scales of hydrated oxide of iron stand out in relief, and are just as numerous and large as in the case of the other vessel. On this occasion I found that the layer of oxide of iron was much thicker at the corners and edges of the sheet iron plates than elsewhere, although the friction must be greater on these prominent parts. This fact escaped my notice with the hull of the *Guienne*.

I think the bubbles are as numerous on the rest of the coat, if not so large as on the *Guienne*. These bubbles may be always divided into two kinds:—

1. Bubbles containing some drops of liquid.
2. Bubbles without liquid, and containing merely air or a gas.

The latter are remarkable for being covered at their base with minute crystals of lead, overlaid with a thin coating of hydrated oxide of iron or yellow ochre. The internal surface of the pellicle of which they are composed, examined with a lens, shows needles of chloride of lead in the midst of slight concretions, which have the appearance of "horn lead" of mineralogists. *Kéraisne.*

The concretions of chloride of lead, which I found afterwards at the base of both kinds of bubbles, on the iron hull, imbedded in magnetic oxide of iron, the dark color of which they relieve by their slightly amber tint.

The liquid contained in the other bubbles I have subjected to a more careful examination. Tested *in situ*, it slightly reddens litmus paper. To the taste at first it is freely styptic and rough, a taste due to the ferrous chloride, as I said in my first paper; to this soon succeeds a sweetish taste, resembling a weak solution of acetate of lead. In my observations on the *Guienne* I recognised, by this taste, the presence of a dissolved salt of lead in the liquid contained in the bubbles. I did not mention it at the time, because I had not determined its nature.

In order to find out, I collected a certain quantity of the liquid by absorbing it with a piece of blotting-paper, when it became easy, by means of distilled water and re-agents, to determine that the liquid consisted of a solution of ferrous and flambic chlorides. Do not these two chlorides form a true soluble saline combination? I am strongly inclined to this opinion. When occasion serves, I propose to revert hereafter to this study. One fact which my experience has taught me is, that solutions of ferrous chloride become, by contact with minium, charged with chloride of lead, as may have been easily foreseen.

The liquid of the bubbles, when exposed to air, quickly becomes covered with a thin pellicle of sesquioxide of iron, without precipitating the slightest trace of chloride of lead. This salt does not appear until only a trace of liquid remains at the bottom of the capsule. By means of the microscope, and even with a lens, it is easy to detect in the midst of the sesquioxide of iron the play of colors of the micaceous spangles of this salt, the deposit of which in the capsule seems to me to be effected in the same manner as if the bubbles were dried.

There was a degree of regularity in the disposition of the concretions on the hull of the *Guienne* which was not to be found on that of *Le Bearn*. In other respects it presents exactly the same foliated structure; it has always externally and at the moment of immersion the same gray color of the iron; then, under this thin envelope, yellow ochre; and at the base the dark green of hydrated ferrous oxide and ferroso-ferric oxides. In all these points the concretions on the two vessels were almost identical. We shall likewise soon establish their chemical identity.

To conclude. Two chemical experiments on a very large scale have been originated in the workshops of La Ciotat. 1200 square metres of sheet iron, covered with linseed oil, and mixed with minium for the first layer, and the same preparation, with the addition of mercuric sulphate (7·5 per cent.), for the second layer, have been launched on the sea: that is to say, that, endowed with a positive electrical polarity (for the hold itself is also painted with minium), this gigantic electrical pair, forming at the same time a kind of condenser, has been plunged into a solution of alkaline chlorides saturated with air. It has then made two or three voyages to Brazil, touching successively at Lisbon,

St. Vincent, Pernambuco, and Bahia, to go into port according to circumstances, either at Rio or Bordeaux. During these long voyages this hull, besides the friction of the water and the shock of the waves, has undergone great inequalities of temperature, which must have caused prodigious dilatations in its metallic sides.

We have now before us the results of these two experiments:—

1. A considerable quantity of oxides of iron (ferroso-ferric oxide predominating) either in concretions or pulverulent.
2. Ferrous chloride.
3. Plumbic chloride.
4. Metallic lead.

Chemical analysis has not hitherto enabled me to discover more than this, either in the concretions or bubbles, besides, of course, minium and the oily menstruum.

The following is the mean of ten analyses made by the same process and under the same conditions:—

	Concretions of the Guienne.	Concretions of Le Bearn.
Sesquioxide of iron,	72·45	70·54
Ferrous chloride,	2·85	2·86
Plumbic chloride dissolved by ferrous chloride	2·80	2·52
Oxide of lead mixed with chloride,	7·30	4·95
Alkaline chlorides,	0·87	1·42
Organic matter,	3·73	4·99
Water,	10·00	12·72
	100·00	100·00

What has become of the mercuric sulphate? Hitherto I have failed to discover any traces of it. The transformation undergone by this salt by reason of the oil with which it is mixed, will be made the subject of another paper.—*Comptes Rendus.*

Nitrate of Soda at Iquique (Peru).

From the Journal of the Society of Arts, No. 476.

As Iquique is the centre of this trade, and to it its present importance is wholly to be attributed, it is thought to be advisable to convey in this paper as much information as can be procured as to this article, and in order that such information shall be truthful, the writer has availed himself of the views of several Englishmen at present engaged in the trade.

About from six to fourteen leagues from the coast, and running parallel with it through the province, at an elevation of 3300 feet or thereabout, is the Pampa of Taramugal. This plain or pampa was a sea lake, and the greater part is covered with salt along the western border; and generally not extending eastwards more than 500 yards from the verge of the old lake is found the "caleche" or "terra sali-

trosa," rough nitrate. Between the pampa and the coasts exists other old sea lakes, on the borders of which "caleche" is also found; but these deposits are of secondary import. The "caleche" is generally found in insulated masses, irregular in shape and thickness, which adds greatly to the expense of working. It is sometimes found with only a few inches of sand over it, but more frequently covered with a hard stone, consisting of sand indurated with salt; this is called "costra," the thickness of which varies from one to ten feet, but averages three feet. The "caleche" varies in thickness from one to nine feet, but in general runs from three to four feet; below this exists a soft sand, containing an abundance of crystals of glauberite and small quantities of borates of lime and soda. The strata consist of

1. Loose sand, a few inches thick.
2. Hard sand, indurated with salt, from one to ten feet thick.
3. "Caleche," from one to nine feet thick.
4. Soft sand, or cora.

The "caleche" varies in quality from nearly pure salt to 50 and 60 per cent. of nitrate, generally containing the following substances:—

Earthy matter.
Nitrate of soda.
Chloride of Sodium.
Sulphate of Soda.
" Lime.
And traces of Chloride of Magnesium, and
Iodides and Bromides.

It is impossible to state the respective proportions, as they vary with every different sample. The method of extracting and refining nitrate of soda is as follows:—

When "caleche" is required, the barretero (miner) makes holes in the ground where he expects to find it. If successful, he fills up the holes with coarse gunpowder made on the spot (costing three and a half dollars per quintal), regulating the charge in proportion to the thickness and hardness of the "costra" and the thickness of the "caleche;" the charge varies from one to eight quintals, and occasionally as much as fourteen quintals; when blasted the whole mass is turned over and mixed. He then proceeds to separate the "costra" and "cora" from the "caleche," throwing aside all the latter that he does not believe to contain more than ten or twelve per cent. of nitrate; it is then broken into smaller lumps, to be conveyed to the "paradas." A refinery of nitrate is called an "Officina," and is generally placed in the centre of the calecheros or nitrate grounds, and consists of one or more paradas; a paradas is a pair of round iron boilers, each holding from 70 to 300 gallons; these are placed together, in rough stone-work, with a fire-place between them. At the parada, the acendrador breaks the lumps into pieces about the size of a fist, rejects the inferior pieces, so as to bring the whole to about 25 to 35 per cent. of nitrate. It is now thrown into the boilers with a quantity of water; after boiling some two or three hours, the fondeador (boiler), continually stirring the mass, supposing that the "caleche"

is by that time exhausted, throws out the ripio (refuse), adds more "caleche" and mother-water; and, after boiling some two or three hours, a well saturated solution is obtained; it is then by hand baled into a deposit, from whence, as soon as the mud and salts are deposited, it is baled into shallow coolers, where it crystallizes. The mother-water is then drawn off, and the nitrate thrown out to dry. The paradas are charged twice a day, and the daily product is from fifteen to twenty quintals of nitrate, containing about 3 per cent. of impurities, chiefly common salt. The average cost of a quintal of nitrate is:—

Barretero, breaking out,	12½ cents.
Acendrador, assorting,	6¼ "
Fondeador, boiling,	12½ "
Powder for blasting,	6¼ "
Asses bringing the caleche to the paradas,	3 "
20 lbs. coals at $1·50 per quintal,	30 "
Wear and tear of parada, reparations, and depreciations,	29½ "
	100 "

This system of making nitrate is the same as was first adopted at the commencement of the trade, and unquestionably well adapted for that early period, having the advantage of being simple, easily understood and worked; yet it is still continued, and the whole system of labor arranged to it. It is almost impossible to conceive a system more rude and more wasteful; and although many exertions have been made during the past ten years without success to improve it, yet that want of success has been caused chiefly by the lack of skilled labor in the province; still there is no doubt that it will be superseded, in the course of a few years, by the more refined and complicated apparatus now being introduced.

The theory of the process of refining nitrate is this:—

"Caleche" consists of nitrate of soda, chloride of sodium, (common salt) and earthy matter (the other substances present exist in such small quantities that they are overlooked); and as chloride of sodium is very little more soluble in boiling than in cold water, whilst nitrate of soda is comparatively insoluble in cold but very soluble in hot water, it is very evident that it is only required to add such quantities of "caleche" to boiling water to procure a strongly saturated solution; the earthy matter, being insoluble, is left with the excess of common salt in the boiler, or the deposit, before it is discharged into the coolers, where, as the liquid cools, it deposits the excess of nitrate of soda, the mother-liquor retaining nearly all the salts in solution. Reverting to the customary process of refining, two systems are now being tried, which use steam; in the one (Gamboni's patent) the "caleche" is placed in an inverted semi-cone, with a perforated cover and bottom; through the side a jet of steam is introduced, mother-water is thrown on the cover, and the refined nitrate falls through the bottom, and is at once conveyed to the coolers; in the other, steam is introduced to boil the solution, but both promise the same advantages—economy in the make and a superior article.

No sketch of the nitrate trade would be complete without some re-

ference to the abuses. In the first place, it is badly based. The merchant makes advances to the salitreros, or officineros (makers), of money and goods, on the promise of receiving in return the product of the officina. This advance frequently is used in paying off old debts, or in advances to the laborers. The merchant must still keep advancing barley for the troops, coals and provisions for the laborers, &c., or there will be no nitrate forthcoming. This system trenches heavily upon the merchant's resources, and occasionally leads to losses. The officineros, as a body (with some exceptions), are a reckless set of men, wasteful in their expenditures and careless of their promises. Their arrangements with their laborers are also bad, their principal ones, the barretero, acendrador, and fondeador, being paid according to the product of the parada; recriminations are ever recurring, and not unfrequently leading to a closing of the works. Another thing must also be noticed—the great amount of adulteration that has taken place within the three past years. Rarely a cargo leaves that is less worse than 5 per cent., some even 7 to 10, and some samples assayed have shown as much as 30 to 50 per cent. of foreign matter. The adulteration is effected in two ways; in one, white "caleche" is ground and mixed with the refined nitrate; this is called green nitrate: the other, the powdered "caleche," is mixed into the solution, and at once put into the coolers; this is dirty nitrate. This is in some measure protected by the present state of the trade. Merchants in England purchase from the importer, and get a deduction from him corresponding to the amount of foreign matter in the article; but as the general sales are made without any deduction, then the worst cargoes are the most profitable to the merchants.

The province has not been thoroughly surveyed; but enough "caleche" has been discovered to yield an increased supply for ages. In May, 1856, there were about 100 officinas at work, with about 250 paradas, but the work is not constant; 240 days is a good year's work. The principal sales of this article are made in Valparaiso on the usual terms, viz: ore well sacked, not to contain less than 95 per cent. of nitrate, placed in the ship's launch outside the surf. The price has been very fluctuating, commencing at 18 reals, rising to 20 reals, falling to 16 reals, and then in four months rising to 23 reals, but taking an average price of 19 reals; 936,719 quintals, with the exchange at $46, would give £426,402 5s. 16¾d. The other salts found in the province are chloride of sodium, biborates of lime and soda, sulphates of lime and soda, magnesian alum, &c. Iodine exists with the nitrate, and throughout the calecheros traces of boracic acid have been found in the water.

Accident to the Iron-clad Steamer Defence.

From the London Artizan, March, 1862.

On the morning of the 22d ult., a serious accident occurred to her Majesty's ship *Defence*, which ship was lying at Spithead. It appears that the *Hunter* gunboat left Portsmouth Harbor on the above morning, and steamed out to the *Defence*. There was a heavy swell run-

ning at the time, and it is asserted that as the *Hunter* went alongside, miscalculating her distance, she ran towards the bow of the ship, the bower-anchor of the latter just touching her side. As the swell lifted the gunboat, it caught the anchor, which broke away from the tumbler, and, after being dragged away by the gunboat, rebounded against the bow of the ship, into the side of which the fluke completely picked a large hole. The iron at the bow is only five-eighths of an inch thick. It is stated that one of the pieces of iron knocked out has been examined, and found to be greatly deficient as regards the welding.

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*Disengaging Catch for the Miner's Safety Cage, &c.** By ROBERT AYTOUN.

From the Lond. Civ. Eng. and Arch. Journal, March, 1861.

All previous disengaging catches with which I am acquainted, are subject to the serious defect of disengaging sometimes when it is not wanted, or of not disengaging when it is wanted; and the means taken to remedy the one defect only make the other more imminent.

The catch which I have invented (Figs. 1, 2, and 3) is entirely free from these faults. It may be described as a species of clasp-knife, which it resembles both in form and the duty it has to perform—viz: that of cutting through an iron bolt, so as to allow the cage being disengaged from the winding-rope, as after mentioned. Its handle, A B C, Fig. 1, and blade, A D E, consist almost entirely of three steel plates closely touching each other. The handle is formed of the two outer

FIG. 1.

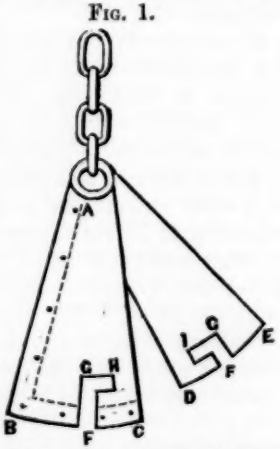


FIG. 2.

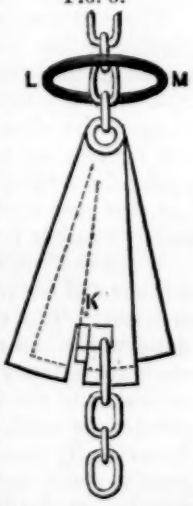
plates, which are separated, as usual in knife handles, by a spring along the back, and which is marked off by dotted lines in the figures. The mid plate represents the blade of the knife, which is not kept shut by its spring as in ordinary knives, but is slightly open. The pin, A, on which the blade turns, serves as the bolt of the shackle, by which it is attached to the winding-rope. The shackle end of the catch is

* Read before the Royal Scottish Society of Arts.

no wider than is necessary for strength. But the lower ends, both of handle and blade, B C and D E, are made somewhat wider, to admit of slots being cut into them, to serve as hooks for suspending the cage. The slots are made thus: having shut the catch, by pushing the blade home into the handle, as in Fig. 2, a vertical slot, F G, is to be cut from the middle of the lower end, right through both handle and blade, of a size sufficient to admit the link by which the cage is to be attached to it. The length of the slot may be twice its width. The blade being now opened, as in Fig. 1, the slots of both handle and blade are to be extended from their upper ends in the direction of each other, that is to H and I respectively. The length of these extensions need not exceed their width.

The action of the slots is as follows:—the catch or knife is first shut, which brings the vertical slots both of the handle and of the blade together, so as to form only a single opening, as in Fig. 2. The link by which the cage is to be fastened to the catch is then pushed up to the top of the vertical slot. Next, the blade is allowed to open by the operation of its spring, by which means the vertical slots, both of the handle and the blade, are moved away from under the link, which now finds itself at the extremities of the side extensions of the slots, resting on their lower sides, as in Fig. 3. In this situation the junction of the cage to the rope is perfect. But its security depends entirely upon the spring; for if it were to allow the blade to shut, the two vertical slots would be brought together, and allow the link to escape, and the cage to drop. To prevent the occurrence of this mishap, to which all previous disengaging catches are liable, a strong bolt of soft iron, whose head is shown at K, Fig. 3, is passed through both handle and blade, and strongly riveted. This secures the catch beyond the possibility of accident, and gives as much security as any link or shackle could do. At the same time, the bolt may be cut, and the blade shut so as to liberate the cage, by the application of sufficient power. For this purpose, a strong iron ring, L M, Fig. 3, within which the winding-rope travels, is secured close below the pit-head pulley. Its diameter is just sufficient to admit of the catch passing through it when closed. In the case of over-winding, when the catch impelled with the whole force of the steam engine and the momentum of the fly-wheel, reaches the iron ring, the blade is at once shut, and the bolt sheared cleanly through, and the cage released. This is shown in the model, in which a bolt of copper is cut through at each experiment. The bolt is not broken, in which case it might be feared that sometimes it would stand the shock and not liberate the cage; on the contrary, it is as cleanly cut as if done with shears provided for the purpose. The reason is obvious; the handle and blade of the catch are composed, as was stated before, of three plates of

Fig. 3.



steel, fitted closely together, and drawn still closer by the riveted bolt, which will not let them part till the cutting of the latter is completed.

I shall have thus, I hope, established my two positions, that the catch cannot be disengaged by accident, and that it cannot fail being disengaged in a case of over-winding. I am happy to be able to add that I have not secured the disengaging catch by patent.

Translated for the Journal of the Franklin Institute.

On the Probable Cause of those Explosions of Steam Boilers called Fulminating. Academy of Sciences of Paris.

Under this title, a note was presented by M. Mangin, the substance of which is as follows:—

It results from the admirable experiments of M. Dufour, that the temperature of water may, under certain circumstances, be brought to 178° Cent. (352·5° Fah.), without the production of boiling. These circumstances are the insulation from contact with the vessel, and insulation from contact with the air. Ebullition is produced by contact with a solid, that is, by the disturbance of the molecular equilibrium, and there is then a sudden evolution of steam. Nevertheless, every solid contact is not equally efficient in producing this change of state, and it results from the experiments of M. Dufour that isolation from contact with the vessel is not absolutely necessary for the production of the phenomenon. What appears to be indispensable is that the water shall be deprived of air, that the operation shall be carried on slowly, and that the heated mass shall be withdrawn from external disturbing causes. Having explained these preliminaries, let us see how the explosions called *fulminating* are to be explained.

These explosions take place only when the machine has been for a greater or less time at rest, and generally at the moment when they are about to resume the movement of the machine; and the boiler by its complete quietness gives no indication of the event. It is enough to open the throttle-valve, or one of the gauge-cocks, or the door of the furnace or ash-pit, or, in fact, any disturbance of the unstable equilibrium which has been established, to decide the catastrophe. It has also been remarked that, before the explosion, the pressure in the boiler is rather low than high. What, then, has taken place?

When the machine was stopped, the pumps were also stopped; the furnace and ash-pit doors were closed, as were all the escapes for steam or water. The ebullition continued, the safety-valve acted, and the water which had recently been pumped in, was purged from air. Then when the activity of the fire had fallen sufficiently, the valve fell into its seat, and the apparatus assumed a state of repose. If the atmosphere was calm, the draft null, and the escapes of water and steam hermetically closed, the apparatus (allow me to use the figure) has gone to sleep, and the molecules of water being at rest, the temperature has gradually been raised to a point notably above that of evaporation under the existing pressure. As the water produces no steam,

that pressure may be and may keep below that necessary for the action of the safety-valve. Things being in this condition, let any cause whatever disturb the equilibrium of the molecules, and all the heat stored up in the liquid mass is instantly employed in producing an enormous volume of steam, while the mass of water not evaporated falls to the temperature corresponding to its pressure.

Figures will easily account for the violence of the explosion which takes place. Let us suppose, in fact, that the pressure in the boiler, before the explosion, was 4 atmospheres, and that the temperature, in the quiescent state of the water, was only 170° Cent. (338° Fah.) As at 4 atmospheres the temperature of the water and steam is 145° Cent. (293° Fah.), each kilogramme of water in the boiler contains 25 units of heat above its normal quantity. Therefore, the moment this heat was liberated, it must have converted into steam $\frac{25}{606{\cdot}5+0{\cdot}305\times145-145}$ or nearly $\frac{1}{20}$th of a kilogramme of water; that is, about one-twentieth of the mass of water in the boiler was suddenly converted into steam.

Now, if we suppose that the volume of water in the boiler was double that of the steam, a quantity of water equal to one-tenth of the volume of the steam is suddenly vaporized; and as, at a pressure of 4 atmospheres, 1 volume of water produces 477 volumes of steam, the volume of the steam will be increased 47 times, and the pressure will be 188 atmospheres. It will be conceived that against such generations of steam, the safety-valves are of no effect, and that the explosions are really fulminating.

This manner of looking at the phenomenon leads to the suggestion of the following precautions. To prevent the *torpor* of the water, let the boiler be so arranged that there shall be a constant circulation kept up by the difference of temperatures of different parts. A second precaution easily taken is never to close a boiler when at rest, hermetically, but to keep the safety-valve slightly raised, or a steam-cock a little open, so that a small quantity of steam may always be forming.

On the Solidification of Carbonic Acid. By MM. A. Loir and Ch. Drion.

From the London Chemical News, No. 84.

In a paper read before the Academy, June 2, 1860, we stated that atmospheric pressure liquefies carbonic acid when its temperature is reduced to the point at which liquid ammonia evaporates *in vacuo*. By slightly modifying the conditions of the experiment, we have succeeded in solidifying carbonic acid with the aid of an apparatus as simple as those daily employed in chemical laboratories. This hitherto dangerous and costly operation may in future be easily repeated to a chemical class.

If liquid ammonia is introduced into a glass globe, and the interior of this put in communication with a good air-pump, by the intervention of a vessel containing coke impregnated with sulphuric acid, the

temperature of the liquid is rapidly reduced from the first strokes of the piston. The liquid begins to solidify towards — 81°; it soon becomes a mass, and if the air-pump allows the reducing of the pressure to about a millimetre of mercury, the temperature of the solid ammonia becomes lowered some degrees more and reaches — 89·5°. This suffices to determine the liquefaction of carbonic acid under atmospheric pressure. We have, in fact, proved that carbonic gas liquefies by passing a current of the dry carbonic acid gas into a small U-shaped tube, immersed in ammonia; but as the temperature obtained is only a few degrees below that of saturation, we get only a small quantity liquefied. If, on the contrary, a slight elevation of pressure is employed, the experiment becomes easy, and yields in a short time notable quantities of solid carbonic acid. The following is the manner of operating:—Introduce about 150 cubic centimetres of liquid ammonia into a reversed glass receiver, the sides of which are cemented to a plate with two holes. In the central opening fit a glass tube, closed internally, and reaching the bottom of the receiver, the other opening serving to place the interior of the receiver in communication with the pneumatic machine. Carbonic acid is produced by heating previously dried bicarbonate of soda in a copper retort, the neck containing fragments of chloride of calcium. One part of this retort communicates by a leaden tube on one hand with the tube which is immersed in liquid ammonia, on the other hand with a small manometer of compressed air. The air being previously expelled from the apparatus, and the temperature of the ammonia lowered to about the point of solidification, the retort is heated, noting meanwhile carefully the pressure. The pressure is thus maintained between three and four atmospheres. Rapidly augmenting transparent crystals soon appear on the sides of the interior tube, so that in about half an hour all that portion of the tube which is plunged in ammonia becomes covered with a thick stratum of crystals (about 25 grammes). The experiment may then be concluded and the apparatus dismounted.

Solid carbonic acid, obtained under the above mentioned conditions, appears a colorless mass as transparent as ice. It is easily detached from the sides of the condensing-tube by means of a glass rod; it then divides into large cubic crystals, each side about three to four millimetres. Exposed to the air, these crystals slowly return to their gaseous state; they evaporate, leaving no residue. Placed on the hand, they communicate no immediate sensation of heat or cold; they are with difficulty held in the fingers, and with a slight pressure escape as if covered with an unctuous matter. If one of these crystals is kept between the thumb and forefinger, it soon produces an intolerable burning.

An experiment was performed by placing a certain quantity of solid carbonic acid in a small glass tube communicating with a receiver filled with mercury. After some time the crystals disappeared, leaving no residue, while the receiver was filled with perfectly pure carbonic gas, capable of being completely absorbed by potash. Mixed with ether, in a small porcelain crucible, these carbonic acid crystals yield a freezing mixture of a temperature of — 81°.

As a conclusion to these summary indications we will add that the liquid ammonia used in our experiments was prepared by M. Bussy's process,—that is to say, by acting on ammoniacal gas in a globe surrounded with liquid sulphurous acid, the evaporation of which is expedited by an air-pump. By this method nearly two decilitres of liquid ammonia can be easily obtained in less than two hours.

We determined the temperatures here indicated by means of an alcoholic thermometer, on which we marked two fixed points,—that is to say, 0° at melting ice, and —40° at the temperature of melting mercury.—*Comptes Rendus.*

On the Boiling-points of Liquids. By M. L. DUFOUR, of Lausanne.

From the Lond. Chemical News, No. 84.

It is an established fact that the temperature of boiling water, instead of being always the same, or varying only with the atmospheric pressure, differs according to the vessel in which the liquid is heated. For instance, water boils sooner in a metal than in a glass vessel, and M. F. Marcet's numerous experiments (*Bibliothèque Universelle*, vol. xxxviii. p. 381) have shown, amongst other things, that the treatment a glass vessel has undergone (as washing in sulphuric acid, &c.) causes several degrees of variation in the boiling point. Water deprived of the air dissolved in it can be re-heated considerably above 100° C. before becoming gaseous, but then it boils violently. Donny, in his interesting experiments (*Annales de Chimie, et de Physique*, third series, vol. xvi. p. 167), carefully heated water completely freed from air, to 135° before a change of condition took place. This retardation of ebullition is manifested also by other liquids, and the production of vapors by starts is a frequent sign of it in glass vessels.

In the actual state of things, boiling produced at a higher temperature than that at which the elastic force of the vapor of the liquid is equal to the external pressure is generally considered as an anomaly due to two causes,—first, the adhesion of the liquid to the substance of the vessel; secondly, the absence of air in solution. There are, however, some curious facts, which show that the adhesion of a solid and the absence of air in solution are inadequate to explain the retardation in boiling; but on the contrary, contact with a solid produces an immediate and decided formation of vapors. If a few drops of water are dropped into linseed oil, heated to 105° or 110° in a porcelain capsule, they fall slowly to the bottom of the vessel. The instant they reach it, vapor is formed suddenly; the slightly diminished drop of water rebounds several millimetres from the bottom, then falls again, causing another disengagement of vapor; again it rises, and so on. Now, it must be remarked that the drops of water, while floating in the oil, before touching the bottom of the vessel, undergo no perceptible evaporation, and that it is only on their contact with a solid that there is a sudden production of a bubble of vapor.

It will, then, be asked, What would happen were the water, while being heated, kept away from the sides of the vessel, floating freely in a medium of a density equal to its own? The proper medium to be

employed in these experiments ought to be able to bear temperatures above 100° without boiling, to be about the same density as water, and not to mix with water. Oils will not do, but certain essences sufficiently fulfil these conditions.

Essence of cloves, with a little oil added, forms a liquid in which water maintains its equilibrium in perfectly rounded drops, and moving about freely in the interior. Carefully heated, the mixture always passes 100° C., and sometimes goes much higher, before the water boils. It is easily and constantly raised to 120°, 130°, and even higher. I have many times raised the temperature of aqueous globules of ten millimetres in diameter, to 140° and 150°. Minute globules, from one to two millimetres in diameter, have several times reached 170°, and even 175°,—that is to say, to temperatures at which the elastic force of aqueous vapor is more than eight atmospheres. I am speaking here of water which has undergone no preparation, which has been neither distilled nor freed from air. At these high temperatures the globules do not undergo, as might be imagined, slow and continuous ebullition; they are as quiet and limpid at 150° as at 10°; it is rather the liquid state continued much beyond the limits corresponding to the pressure under which the operation is performed.

Ebullition is produced when the globules come in contact with a solid. If, drawn by the currents which heating inevitably occasions, they strike against the sides of the vessel or the bulb of the thermometer, there is suddenly formed a bubble of vapor; the globule, become rather smaller, is projected violently from the point at which it produced this kind of explosion, and then continues floating in the medium. The result is the same if, when the temperature is above 115° or 120°, a globule is touched with a glass or metal rod; an explosion is produced at the point of contact, a bubble of vapor is disengaged and passes through the essence, and the globule touched rebounds as though the solid point exercised a sudden repulsion over it. However, all solids are not equally efficacious in producing this change of state; glass or metal rods sometimes fail, but a slender wooden or charcoal stick always incites an immediate and tumultuous ebullition in the middle of the overheated globules. Contact with saline crystals is generally very efficacious.

It is difficult to preserve large globules from contact with the sides; hence they are the seat of the formation of vapor on one point of their surface, which has the effect generally of breaking them up into smaller globules. In my experiments, the vessels employed were small glass globes, and I have already easily obtained a globule of eighteen millimetres, at 130° C., and others of six to ten millimetres at 150° C., &c. The smallest globules most readily escape contact with the sides, and can be submitted to a higher temperature.

It may well be supposed that the preceding facts may be realized with other liquids if heated under proper conditions. This supposition is confirmed by the experiments I am now making. For instance, chloroform, heated in a concentrated solution of chloride of zinc, easily reaches 90° and 100°. The chloroform globules float lightly

in this liquid, like water globules in essence of cloves. Beyond 70° contact with a solid rod produces decided and violent evaporation.

It is difficult not to connect these facts with those in which contact with a solid causes the crystallization of super saturated saline solutions, and also the sudden solidification of water, sulphur, &c., when brought below their ordinary temperature for solidifying. It is equally difficult to disconnect them from the facts which I have lately had the honor to bring before the Academy,—facts which showed that liquids resist solidification when immersed in a fluid medium. It appears that contact with a solid determines a change of state in liquids, and it may be that the limits of temperature assigned to the various conditions of bodies are not so absolute as they seem. Our experiments on liquids, always made in vessels in contact with solid bodies, may perhaps have led us wrongly to consider, as inherent properties of the liquids themselves, the phenomena resulting, at least in part, from the presence of solids. Thus, when water floats freely in a fluid it rarely freezes at 0°, and it is only changed into vapor at a point of the thermometric scale always exceeding 100°.—*Comptes-Rendus.*

Preservation of Meats.

At the last meeting of the Society for the Encouragement of National Industry, M. Peligot read the following note of M. Martin de Lignac on his new patented process for the preservation of meats:—

In the usual way of salting, the meat is placed first in salt and afterwards in the pickle. The salt absorbs the liquids in proportion as they separate from the flesh, then the pickle penetrates by endosmose, and preserves them from any subsequent alteration by its antiseptic properties. But in this case, the salt acts on the surface a long time before it penetrates to the centre, whence results an excess of salt at the surface, whilst the centre is not sufficiently salted and still contains the principles of fermentation. To avoid this, the habit is to cut up the meat, but this, while it increases the chances of its preservation, greatly alters its quality. In fact, the salt in contact with large surfaces absorbs too largely the liquids contained in the flesh, and extracts from them the aroma and a portion of their nutritive juices. Pork, the tissue of which is dense and protected by fat, bears this preparation better than beef, the flesh of which after long standing in the salt, presents only a fibrous tissue without flavor and with but a low nutritive power.

It results from these facts; first, that meat preserved by the usual process contains necessarily too much salt, and that its prolonged use is injurious to health; secondly, that it loses a part, sometimes a notable part of its nutritive value.

The method of avoiding these inconveniences is to salt uniformly and not subdivide too far the meat, thus preserving its aroma and its juices; I think that I have found the solution of this problem, and the following are the means which I employ:

If it is a ham which I wish to salt, I introduce, by means of a trocar,

between the bone and the muscle at the small end, a sound which I attach to a stop-cock which communicates by a tube with a reservoir of water saturated with salt, to which are added various aromatics and condiments. The reservoir is from 25 to 35 feet high. When the stop-cock is opened, the liquid by its pressure rapidly separates the muscle, and the two or three ounces of pickle which are necessary for the preparation of one pound of meat, are easily lodged in the cellular tissue which surrounds the bone. Thence it forms a kind of reservoir, the liquid spreads penetrating all the fibres by infiltration, distributing regularly and homogeneously the conservative agent, and producing its first effect upon the parts most susceptible of alteration, that which surrounds the bone. The ham thus prepared is put for some days in a pickle-bath. The object of this bath is to prevent by its pressure, the issue of the liquid injected; besides which it completes the preparation by saturating the surface. When they leave the bath, the meat has lost nothing of the weight which it had at its entrance. I then expose it to a current of air at a moderate temperature. When by evaporation, they have lost the infiltrated liquid and 5 per cent. of their normal weight, I expose them to the action of smoke for a time which varies with their weight. This latter operation is not necessary for their preservation, but it gives them a taste which is generally sought for, and effects a reduction of weight. On leaving the smoke-house they have lost from 12 to 15 per cent. of their weight; before entering they had already lost about 5 per cent., so that their whole loss is from 18 to 20 per cent.—*Cosmos.*

For the Journal of the Franklin Institute.

Decision of the U. S. Patent Office on the Application of W. J. Cantelo for a Patent for Manufacturing Cordage, Paper, &c. April 15, 1862. Reported by H. Howson, Esq., Philadelphia.

On Appeal to the Examiners in Chief.

The applicant claims to have discovered that cordage, paper, &c., may be manufactured to advantage out of the hibiscus moscheutos, or hibiscus palustris, and he describes the process, in which there is no especial novelty, and claims a patent. The objections raised against his petition are threefold.

In the first place, it is said that a patent has been already granted to one Jean Blanc, 24th June, 1851, for the manufacture of cordage, &c., out of the okra plant, or hibiscus esculentus. This is of the same botanical genus as the hibiscus moscheutos, and it is asserted that in plants of the same genus, the resemblance between their properties is so uniform and so great, that those that are found in any one may be presumed to exist in every other of the same genus. This can hardly be said to hold true in all cases, nor in so large a proportion as to furnish any rule. The genera of plants are arranged according to certain distinguishing features in them, which by no means indicate their peculiar characteristics.

It is true, that in some cases those of a particular genus are, many

of them, found to possess common qualities. But this is by no means universally true. The vegetables of many of the genera are widely different in their virtues and powers. The broomcorn, for instance, would never lead any one to suspect the peculiar merits of the Chinese sugar cane, the sorghum saccharatum, although both are of the same genus. Many other examples of this might be named. And the number of species under each head is so great, that it would be entirely unsafe to infer the character of one from that of another, and unjust to deny invention to him who discovers in one, the properties which had before been known to exist in another. The application of J. B. Read, rejected 14th February, 1859, for making paper out of the okra plant, which was mentioned, must be disposed of upon the same considerations.

Reference was made also to William Johnson's English patent, No. 135, for 1855, for manufacturing paper, &c., out of plants of the order Malvaceæ, which embraces among several other genera that of the hibiscus. But if we cannot infer from the nature of one plant, that of another of the same genus, much less can we that of others of the same order. In fact, plants which possess hardly any useful properties in common, are frequently embraced under this division. It may well be questioned, therefore, whether a patent which supposes all the plants of an order to be capable of the same uses, can be valid. Certainly it cannot be, unless the supposition is true. Now there are many of the Malvaceæ which have no such supply of fibre, as to warrant any attempt to manufacture them into cordage or paper. Add to this the fact, established by affidavit, that the hibiscus moscheutos is not indigenous in England, and is known only as a rare exotic, if at all, and the supposition that it is embraced in the English patent, becomes manifestly preposterous. Another reason for disregarding the English patent is, the very large number of vegetables embraced in it. It cannot be well supposed, that any one person can have ascertained the nature of every species, included under the various divisions named, so as to ascertain how far each is available for the object in view. The conviction must force itself upon every one, that many of them are named merely from conjecture. To allow any one to monopolize the use of all that may come within the description, without distinguishing those that are of use from those that are not, is an abuse of the patent law, which ought not to be sanctioned.

It is further alleged, that the capacity of all vegetable fibre to be manufactured into paper has become so well established, that the selection of any particular plant for that purpose is no longer regarded as deserving of protection.

It has always been the practice of the Patent Office, notwithstanding, to reward any one who discovers that any particular plant possesses properties especially favorable for any manufacture. The patent of Jean Blanc shows this, and there are many others of the same kind.

It is considered that there is error in the decision of the Examiner, and it is reversed.

New Chronograph.

M. Lissajous presented to the Academy of Sciences of Paris, in his own name and that of Captain Schultz of the Artillery, a new instrument for measuring small intervals of time, by which he proposes to estimate accurately the five-hundred-thousandth part of a second. The instrument is to be composed (for it is not made yet) of, 1, A silvered drum about 40 ins. in circumference, which is to be coated with lampblack for the experiment: it makes three turns per second. 2, A tuning-fork giving five hundred vibrations per second, with the electric apparatus for preserving its vibrations according to the plan of M. Lissajous; a point fixed upon this, marks on the drum during the experiment. 3, An electrical apparatus to give a spark at the beginning and end of each phenomenon according to the plan of M. Martin de Brettes. That which characterizes the new apparatus is the length of the line on the drum, which corresponds to the very short duration of the phenomenon, and the facility of dividing it by the microscope.

Cosmos.

[This appears to be an improvement on the electric chronograph of Prof. Henry—described in the Proceedings of the American Philosophical Society, and which has been so extensively re-invented without acknowledgment in France, England, and elsewhere.

ED. JOUR. FR. INST.]

On the Manufacture of Strings for Musical Instruments, and other uses, of Gut and Sinew.

From the Lond. Mechanics' Magazine, December, 1861.

A manufacture of which comparatively little is known, is the preparation of the substance usually termed catgut, though for the most part made from the dried, twisted, peritoneal coverings of the intestines of sheep. Catgut cord is used for a variety of purposes where strength and tension are required, as for the strings of musical instruments, for suspending clock-weights, bow-strings for hatters use, and for archers bows.

The manufacture of musical strings requires a great amount of care and skill, both in the choice of materials and in the manufacturing processes, in order to obtain strings combining the two qualities of resistance to a given tension and sonority. Until the beginning of the last century, Italy had the entire monopoly of this trade, and they were imported under the names of harplings, catlings, lute-strings, &c.; but the trade is now carried out with more or less success in every part of Europe. However, in the opinion of musicians, Naples still maintains the reputation of making the best small violin strings, because the Italian sheep, from their leanness, afford the most suitable material; it being a well ascertained fact, that the membranes of lean animals are much tougher than those of high condition. The smallest violin strings are formed by the union of three guts of a lamb (not over one year old), spun together.

The chief difficulty in this manufacture is in finding guts having the qualities before mentioned—namely, to resist tension, and giving

also good vibrating sounds. It is far more easy to arrive at the proper point in the making of harp, double-bass, and other musical strings, and the manufacturer is not so much circumscribed in the choice of the proper material. The tension upon the smallest string of the violin, which is made of only three guts, is nearly double that on the second string, formed by the reunion of six guts of the same size.

In the preparation, the sheeps guts, well washed and scoured, are steeped in a weak solution of carbonate of potash, and then scraped by means of a reed cut into the shape of a knife. This operation is repeated twice a day, and during three or four days, the guts being every time put into a fresh solution of carbonate of potash, prepared to the proper strength. In order to have good musical strings, it is indispensable to avoid putrid fermentation; and as soon as the guts rise to the surface of the water, and bubbles of gas begin to be evolved from them, they are immediately spun.

In spinning, the guts are chosen according to their size; combined with three or more, according to the volume of the string required, they are fastened upon a frame, and then alternately put in connexion with the spinning-wheel, and submitted to the required torsion. This operation performed, the strings, left upon the frame, are exposed for some hours to the vapor of sulphur, rubbed with a horse-hair glove, submitted to a new torsion, sulphured again, further rubbed, and dried.

The dried strings, rolled upon a cylinder and tied, are rubbed with fine olive oil, to which one per cent. of laurel oil has been previously added. The oil of laurel is supposed to keep the olive oil from becoming rancid.

The gut-strings employed by turners, grinders, and for cleaning cotton, &c., are made with the intestines of oxen, horses, and other animals. These, cleared by putrefaction of the mucous and peritoneal membranes, and treated by a solution of carbonate of potash, are cut into straps by means of a peculiar knife, and spun in the same way as the musical strings. The uses of bladders and gut for holding lard, for covering gallipots and jars with preserves, as cases for sausages, polonies, &c., and other domestic purposes, are well known. Lately, however, the vegetable parchment, as it is termed (which is ordinary paper steeped in sulphuric acid), has come into extensive use for this purpose.

Insufflated, or inflated guts, are chiefly employed for the preservation of alimentary food. They have to pass through a long series of modifications and processes, before becoming fit for use. The end of these preparations is, to free the muscular membrane of the intestine from the two other membranes covering it, the peritoneal and the mucous.

The first operation of scouring consists in freeing, by means of a knife, the gut from the grease attached to it, and also of the greatest part of the peritoneal membrane. The scoured guts are washed and turned inside out, then tied together, put into a vat without any more water than that adhering to them, and left in this state to undergo a putrid fermentation. The time required for this operation will be from

five to eight days in winter, and two or three days only in summer. If the fermentation were pushed too far, the guts would be disorganized: to avoid this inconvenience, the workmen are often obliged to add some vinegar, in order to neutralize the ammoniacal compounds formed, and also because fermentation is slow in the presence of acids. After this fermentation, the mucous membrane is completely decomposed, and the remaining portions of the peritoneal membrane are easily taken off. The guts are then well washed, and insufflated (inflated).

This operation is performed in the same way as swelling a bladder, with this difference, that the extremity of the gut is tied by a ligature serving also to join a new gut insufflated (inflated) in the same way. During this operation, the guts exhale the most noxious smell, and workmen employed at such work could not blow or insufflate many days in succession without having their health affected.

In order to prevent that inconvenient, unhealthy process of manufacture, the *Société d'Encouragement* of Paris proposed a premium for a chemical process enabling the manufacturers of these articles to dispense with putrid fermentation. The process suggested by Mons. Labarraque, the successful candidate, is remarkable for its cheapness and the facility of its application. In following the method recommended by this chemist, these animal matters can be worked more easily, and kept for a longer time without evolving any noxious smell.

The guts, previously scoured, are put into a vat containing, for every forty guts, four gallons of water, to which 1½ pounds (*Eau de Javelle*) oxichloride of sodium, marking 13° on the areometer of Beaumé, is added. After twelve hours of maceration, the mucous membrane is easily detached, and the guts are free from any bad smell; by this method, the process of insufflation is more easily performed.

The insufflated guts are suspended in a dry room until the desiccation is complete; and, once dried, the extremities by which they were tied together are cut, and in pressing the hand over the length of the insufflated (inflated) gut, the air inside is completely taken out. The guts are then submitted to fumigation by sulphur, in order to bleach and to preserve them from the attacks of insects. After this last operation, the guts are fit for use.

Besides our large home supply of bladders, we import several hundred thousand a year, packed in salt and pickle, from America and the Continent, and the aggregate value of the bladders used in this country is stated at £40,000 or £50,000.

The use of the reindeer-sinew for lashing and binding purposes on implements, &c., is common from Norway and Lapland, along the entire coast of Asia and America, even as low as 36° N. in California, and continued on the coast-line up to the easternmost point of America, and again at Greenland. Sir E. Belcher, in Transactions of the Ethnological Society of London, states that he traced this custom of using the reindeer-sinews continuously on the western coast as far south as the thirty-sixth parallel on the coast of California, where the Mexican Indians soak it and form it into layers, in which they enclose

the wood of the bow entirely. The horns of the bow are also moulded of it; and when dry, it presents the dull-grey translucent features of horn.—*The Technologist.*

For the Journal of the Franklin Institute.

Durability of Hemlock. By T. GUILFORD SMITH, C. E. M. and B. M. Railroad.

To the Editor of the Journ. of the Frankl. Insti.

SIR:—In laying pipes to supply a water station on the top of the Broad Mountain, in Schuylkill County, on the line of the Mahanoy and Broad Mountain Railroad, we found it convenient to make use of the dam, and to follow the ditch originally made by the Danville and Pottsville Railroad Company, 32 years ago.

To our surprise, we found the hemlock trees which had been bored for pipes, in a perfect state of preservation, wherever submerged or surrounded by moist earth. The bark was still adhering, and the sap-wood presented that rosy hue seen in freshly felled hemlock. Wherever, on the contrary, the surroundings were dry, the timber was decayed.

The pipes varied in depth beneath the surface of the ground from 1½ to 2 feet. They were in excellent condition for over 1000 feet in a continuous line.

ASHLAND, Penna., May 20th, 1862.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, May 15, 1862.

John Agnew, Vice President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Letters were read from Col. H. Bache, Bureau U. S. Topographical Engineers, Washington, D. C., and Thomas Oldham, Esq., Superintendent of the Geological Survey of India, Calcutta.

Donations to the Library were received from the Royal Institution, the Royal Astronomical Society, the Institute of Actuaries, and the Statistical Society of London; Thos. Oldham, Superintendent of the Geological Survey of India, Calcutta; the K. K. Geographischen Gesellschaft, the K. K. Geologischen Reichenstalt, the Oesterreichischen Ingenieur-Vereines, and the Nieder-Osterreichischen Gewerbe-Vereines, Vienna, Austria; the Bureau of Topographical Engineers, and F. Emerick, Esq., Washington, D. C.; F. W. Bird, Esq., Boston, Mass.; Thomas Ewbank, Esq., City of New York; Dr. G. Emerson, A. B. Hutton, Esq., J. C. Beckel, Esq., Geo. R. Smith, Esq., Messrs. M. W. Baldwin & Co., Joseph Hutchinson, Esq., John C. Trautwine, Esq., and George M. Conarroe, Esq., Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of April was read.

The Board of Managers and Standing Committees reported their minutes.

Candidate for membership in the Institute (1) was proposed, and the candidates proposed at the last meeting (9) were duly elected.

Mr. Howson exhibited a Bowie Knife, taken from Fort Donelson two days after the battle, and sent to W. F. Hall, Esq., of St. Louis. Mr. H. said that the weapon was well worth the attention of the members on account of the peculiarly crude workmanship displayed in its construction; that it was originally an ordinary file, and had a rough hickory handle and a guard attached to the shank.

Mr. Howson also exhibited specimens of the fibre of a plant termed *Hibiscus Moscheutos*, or *Palustris*, and remarked that he had shown similar specimens about a year ago, but now repeated the exhibition, owing to the importance attached to the discovery, not only by eminent naturalists, but by the authorities of the Patent Office, who have this week issued letters patent to Mr. Cantelo, the discoverer, and to his assignees, Messrs. Stuart and Peterson, for the exclusive use of the fibres of the plant in question, for the manufacture of paper, cordage, textile fabrics, matting, &c.* It would be a difficult matter to distinguish the specimens of rope made of this fibre from the best hempen rope, which it equals in strength and durability. Serviceable matting and excellent paper may be made from the fibre, which can, by the aid of proper machinery and appliances, be converted into valuable textile fabrics. The hibiscus moscheutos grows wild in the marshy grounds of most of the northern States, and is especially abundant in New Jersey.

A breech-loading Cannon, the invention of W. O. B. Merrill, Esq., of this city, was exhibited by Mr. Howson. To the rear of the barrel is permanently attached a yoke, in which works a movable breech, kept in its proper position in relation to the barrel by lugs, which project from it, and slide on ledges formed on each side of the yoke. To load the cannon, the breech is slid back, and tilted so as to expose the chamber, into which the cartridge is dropped. The breech is then brought to a horizontal position, pushed forward, and forced tightly against the rear of the barrel by a screw which passes through the yoke in a line with the bore.

W. W. W. Wood, Esq., Chief Engineer U. S. N., exhibited a model of his improved Armor for ships of war. His method of plating ships has been submitted to the leading engineers and ship-builders of the city, who have declared it superior to any of the numerous plans proposed for accomplishing the same object; the plating being stronger in proportion to the weight of metal, more economical, and capable of being attached to the sides with much greater facility than by other methods. The most important feature is the manner in which the plates

* See page 406, "Decision of the United States Patent Office."

are bolted to the vessel, without exposing the heads of the bolts where they can be struck by shot, thus rendering the stripping off of the plate by this means impossible.

George McIlvain, Esq., of this city, exhibited a Case for Gas and Hydrant Stops in pavements, made of terra cotta, much more durable than wood, and not liable to swell, so as to cause the top of the case to protrude above the pavement.

Jacob Ruth, Esq., exhibited an Apparatus for removing Invalids. It is an apparatus by which the heaviest person can be moved with ease by one person, with no pain to the invalid. Physicians who have used this apparatus in the Government hospitals, have pronounced it an important and valuable invention.

Mr. John W. Nystrom exhibited some specimens of Iron and Steel, manufactured at his establishment, Gloucester, N. J., by the process known as Bessemer's, and made the following observations:

The cast iron is smelted in an ordinary cupola, from which it is run into a barrel-shaped furnace, where air is blown into the molten iron for about 10 to 15 minutes, the time required for decarbonizing it to steel or wrought iron; after which it is run direct from the steel furnace into moulds of any desired shape. Ingots thus cast can be taken direct to a rolling mill or steam hammer, and worked in the one original heat.

The steel furnace now in operation is for acting on 3000 lbs. cast iron at a time, which gives about 2500 lbs. of wrought iron or steel. The specimens exhibited are, one steel plate of about $\frac{3}{16}$ inch thick, and one $\frac{5}{8}$ inch round iron bar, both of which are rolled out direct from ingots cast in sand moulds; also, one steel ingot and a piece of oxide of iron.

The cast iron thus far operated upon has been mostly the Allentown anthracite iron, No. 2, and two operations with charcoal iron. I am inclined to believe that, with some experience, good iron and steel may by this process be made from any kind of cast iron.

Armor plates can by this process be cast into any size and shape; also, cast steel and wrought iron guns, and a variety of articles made by the complicated and laborious process of puddling, rolling, welding, and forging, can by this process be made into shape of the purest iron or steel in one heat. The great heat generated in the steel furnace enables the decarbonized iron to remain for some time in a perfectly fluid state, allowing the lighter impurities to rise to the surface in form of slag, and the pure metal to run into moulds. In puddling furnaces, the decarbonized iron cannot attain so high a heat as to be kept in a fluid state, but of the consistence of dough, intermixed with and rolling in a fluid slag, which is partly squeezed out under a hammer or squeezer, after which the iron bloom is rolled out to a bar. This bar is cut in pieces, piled up into a packet, heated and rolled, which operation is repeated several times before good iron is obtained, and every time the iron passes through the rollers, slag is squeezed out of it; while by the process known as Bessemer's, the ingots roll-

ed out to finished iron in the first original heat, slag is hardly perceptible.

The Bessemer process has in the last five or six years gone through the different stages of success, failure, ridicule, and criticism, customary to every good thing, and is now in successful operation in several places in England and Sweden. The only difficulty I have to contend with in carrying on the process is the want of capital; as it is a new thing in this country, it is hard to convince capitalists of its great importance.

A great many parts of machinery which in Europe are made of wrought iron or steel, are in this country made of cast iron; now, by this process, such parts can be cast direct of steel or iron, which will materially reduce the weight and increase the durability of the machinery. I consider the process to be of the greatest importance for railroad iron, such as wheels, tyres, frog-plates, rails, &c. I am inclined to believe, that by this process cast steel rails can be made at the same price as that of the present puddled rails. Such cast steel rails would not only stand perhaps four times as long as iron rails, but it would increase safety and comfort on the road in the same proportion.

Samuel Sartain, Esq., engraver, of this city, exhibited an impression of a large Map, devised and executed on a new and effective plan by Col. Baron Egloffstein, U. S. A. It illustrates the labors of the U. S. expedition for exploring the *Colorado River of the West* and surrounding country in New Mexico.

Baron Egloffstein, the topographer of the expedition, conceived the idea of endeavoring to give his map the appearance of a small plaster model of the country; and to do this he treats the forms of nature as an artist would draw any form before him—that is, by giving the real light and shade that would be developed by light falling on the model at a suitable angle. The mountains have their shadow-side engraved in the usual manner by "*hachures*," but the light-side is only slightly tinted in parts to develop detail of form, and is brilliantly relieved by a tint spreading over the level plain like an India-ink wash; this tint is made of several grades of strength, intended to show the *relative altitude* of the several plateaus over which it is spread, the lowest or alluvial lands having the darkest tint, and the loftiest table-lands having the most delicate.

The result in the present map is bold and striking, showing at a glance the nature of the whole country, enabling any one to perceive the character, prominence, and relation of the different parts. This region of country has features unsurpassed in their kind for grandeur and sublimity; the Colorado of the West flows for 300 miles of its course through Cañons whose sides often rise perpendicularly from 3000 to 6000 feet in height; the "Great Cañon of the Colorado" is the most magnificent gorge as well as the grandest geological section of which we have any knowledge. For this region, Col. Egloffstein's system of mapping has unquestionable advantages; its freedom from conventionality and truth to nature, give it a power, unattainable by

the old system, of representing forms so that they are intelligible to every eye.

The French at one time used a system of topography similar to this; it had light-sides and shade-sides to the mountains, but they did not tint the level plain, on which so much of the character and beauty of this style depends. The tint on the steel plate shown, is machine-ruled (nearly 200 lines to the inch), and graded to the requisite strengths by acid, giving by its fineness the appearance of delicate India-ink tints; this portion of the work was executed by Mr. Samuel Sartain, and excels as a specimen of this method of engraving.

Col. Egloffstein deserves the thanks of the *public* for enabling them to read some of the results of scientific labors with an *ease* that was before only possible to the professional topographer, and at perhaps less expense than by the old system.

Mr. A. L. Fleury read the following paper:

My esteemed friend, Mr. Frederick Ruschhaupt, a very able technical chemist of Berlin, has lately patented a most simple, economical, and useful Apparatus for generating Carbonic Acid and other gases; he has forwarded to me the drawing which is here exhibited.

The apparatus consists of a strong wooden tub or vessel, 2 feet high and 17 inches wide, having a partition near the middle. The whole inside of both partitions is lined with lead. From the upper part of the wider partition a leaden pipe leads near to the bottom of the smaller partition. A leaden vessel, perforated with holes at the bottom, is filled with carbonate of lime, marble pieces, say 6 lbs., and dipped by means of a sliding rod into the larger partition, containing about 7 lbs. of hydrochloric acid. The other (smaller) partition is half filled with pure water, having a glove-valve as outlet. The vessel is closed air-tight by a strongly braced cover.

Whenever a supply of carbonic acid is desired, the lead vessel containing the marble pieces is slid into the acid, which, passing through the leaden tube, under and through the water in the next partition, to the glove-valve (for the purpose of purifying the gas from any foreign matter or chlorine carried over with the carbonic acid), is by means of suitable pipes conveyed wherever it may be desired. When the marble, which is a chemical combination of lime with carbonic acid (56·09 lime with 43·91 carbonic acid), is dipped into the hydrochloric acid, the carbonic acid is thereby expelled, the lime combining with the chlorine to form chloride of lime, which, after all the carbonic acid is expelled, can be taken from the gas apparatus by a syphon without taking off the cover, and may afterwards be used for the purpose of bleaching, &c.

Six pounds of marble dust and seven pounds of hydrochloric acid will furnish about 170 *gallons of carbonic acid gas; and all this at a cost of about* 18 *cents!*

There is no danger of explosion, as in the ordinary copper apparatus, because the pressure can never rise sufficiently high, and the evolution of gas can be stopped at any moment by withdrawing the sliding

rod which dipped the marble into the acid; moreover, if desired, though not imminently necessary, a safety valve as well as pressure gauge may be put on. The beautiful simplicity of the apparatus, its safety, its easy management by the most ignorant person, *and above all, its low price*, making it accessible to all classes, are the best recommendations to the public at large.

I will here enumerate some of the most prominent applications. The hot season is now upon us, and who is not fond of a fresh and sparkling glass of soda water or lager beer? The gradual loss of carbonic acid in lager beer causes this beverage to become bitter and of a disagreeable taste; it makes it unwholesome and productive of headache. Some men, not familiar with the chemical requisites of good, healthy beer, attempt to overcome this evil by injecting atmospheric air—the very means of forcibly driving off what they should most necessarily keep in.

By means of this cheap gas apparatus, lager beer can not only be kept continually fresh and impregnated with carbonic acid gas, but also by a proper arrangement of tubes forced up by it, fresh and sparkling to the last drop. The same may be applied to soda water, lemonade, wine, and other beverages.

I would here draw attention to the adaptability of Mr. Ruschhaupt's gas generator for the easy preparation of ferro-carburetted water, a water containing oxide of iron in solution. This peculiar beverage is considered by some eminent European physicians a powerful preventive and remedy for debility; even cases of consumption are said to have been cured.

The manufacturers of white lead, of bicarbonate of soda, of hydrate of silica, and others, may perhaps find this apparatus more convenient than their present arrangements.

Bakers and hotel keepers are thereby enabled to prepare the finest and most wholesome aërated bread, without yeast or soda powders, more effectively and cheaper than in the present way.

The chemist will find this apparatus of great value in his laboratory: its use is not confined to carbonic acid gas alone; hydrogen, chlorine, sulphuretted hydrogen, hydrocarbons, and other gases can thereby be most economically and speedily evolved.

The same gentleman has invented an excellent apparatus for producing Artificial Ice, by exhausting and compressing ammonia gas in a separate vessel, now exploited by a New Haven company. I hope Mr. Ruschhaupt may be able, by proving the priority of his invention, to reap some benefit for his arduous labors.

Mr. John Warner submitted to the meeting his Stereometric Tablet, together with diagrams showing his new system for the computation of earthwork (which subject he has more fully shown in a work published by him*), and made the following explanation:—

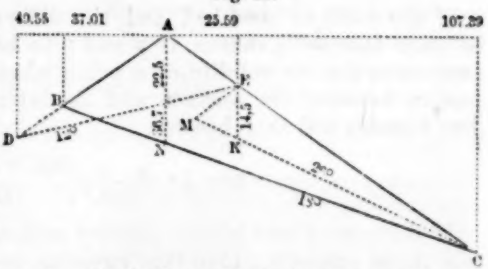
* New Theorems, Tables, and Diagrams, for the Computation of Earthwork: designed for the use of engineers in preliminary and final estimates, of students in engineering, and of contractors, and other non-professional computers. Illustrated by original engravings, and a series of lithographic drawings from models showing all the combinations of solid forms which occur in railroad excavations and embankments. Octavo, 316 pages. Philadelphia, J. B. Lippincott & Co., 1861.

The Stereometric Tablet is intended to assist computation of earth-work by the method of Transverse Ground-Slopes. This method is much used for preliminary estimates. The measurements taken on the field are, the length of the work, and, at each end, the centre-height, and the inclination to the horizon of the surface-line of the cross section. We shall assume the surface-line of the cross section to be everywhere straight, and the surface of the ground to be a warped surface, generated by the motion of this straight line moving parallel to the vertical end planes of the work, and resting upon two straight directrices. These directrices are supposed to be the outside bounding lines of the ground surface.

In order to exhibit the cubature of the solids in question, we shall suppose both the end cross sections to be plotted in the same figure. We shall, at first, consider the whole cross section which is formed by prolonging the side slopes until they meet—that is, we shall consider the whole solidity contained between the ground surface and the intersection of the side slopes.

Let A B C, fig. 45,* represent one entire end cross section, and A D E the other. Through E, the point where the side slope A C of one end is cut, on the drawing, by D E, the surface slope of the other end, draw E M parallel to the other side slope, and make E M = B D, the difference in length of the side slopes A D and A B. Join M with the angle C, and draw the vertical line E K. The height E K, and the inclination of C M to the horizon (or the surface slope of C M), may be easily measured on the diagram. A similar and equivalent result will be obtained by drawing a line B M through B, making B M parallel and equal to E C, joining D M and drawing B K. The construction is not shown in the figure.

Fig. 45.



The solidity, as we have elsewhere shown, consists of two terms. The first, or principal term, is a prism having the same length as the work, and for its base the whole cross section taken in the middle of the work. This cross section is readily found by a construction which we shall briefly indicate.

Bisect B D and E C, and join the two points of bisection; the line joining them will be the surface of the mid-section. The height to this surface, and its slope, can then be measured.

The second term of the solidity is the *one-twelfth* part of a prism of the same length, and standing on the base, C M E. This second term may be called the *correction*, because the first term may be con-

* This figure has been transferred from the stereotype plates of the writer's treatise, and contains some lines not necessary to our present purpose. In order not to make similar transfers too frequent, we have been obliged to avoid entering here at greater length into the mathematical theory of our subject.

sidered as an approximate result, which may be corrected, if desired, by means of the second term. The correction is additive if the directrices are inclined in the same direction, otherwise it is subtractive. Whenever A B = A D or A E = A C, the correction vanishes.

The computation of solids under the warped surface proposed, is, therefore, reduced to the computation of solids under plane surfaces. When the surface slope is the same at each end of the work, the ground surface becomes a plane. In this case, C M has the original slope of the ground, and E K = the difference of the centre-heights.

We shall now consider the method of finding the solidity of a prismoid or prism by means of the Tablet. This being done, the solidities of the two prisms above described may be found, if required.

Let L = the length of the work, B = the width of road-bed, S = the sum of the whole heights similar to A N, at each end of the work (called *augmented centre-heights*), and let D = the difference of these heights. Also, let the side slope, or angle C A 107·39 = σ, and the surface slope, or inclination of C B to the horizon = γ. Let V be the volume of the prismoid contained between the ground surface and the road-bed: then our formula is

$$V = \tfrac{1}{4} L \left(S^2 - B^2 \tan.^2 \sigma + B^2 \tan.^2 \gamma + \frac{D^2}{3} \right) \frac{\tan. \sigma}{\tan.^2 \sigma - \tan.^2 \gamma} \quad \text{(A.)}^*$$

If the width of road-bed and the difference of the centre-heights be made both = 0, that is, if B and D be both = 0, we shall have an expression for the solidity of a prism whose base is the whole cross section between the surface and the intersection of the side slopes. The formula will then become

$$V = \tfrac{1}{4} L S^2 \frac{\tan. \sigma}{\tan.^2 \sigma - \tan.^2 \gamma} \quad \text{(B.)}^\dagger$$

If the square root of the quantity within the parenthesis, in equation A, be put = S_1, then that equation may be put under the form

$$V = \tfrac{1}{4} L S_1^2 \frac{\tan. \sigma}{\tan.^2 \sigma - \tan.^2 \gamma} \quad \text{(C.)}$$

Equations B and C are evidently of the same form. The quantity S_1 may readily be found by a construction which we shall not now describe. Hence the resolution of equation B or C by means of the Tablet, will suffice for computing prismoids under plane ground, or the first and second terms above required for work under a warped surface.

Equation B may be put under the form

$$V = \tfrac{1}{4} L S^2 \frac{\cot. \sigma}{1 - \dfrac{\tan.^2 \gamma}{\tan.^2 \sigma}};$$

* See Treatise, page 281.

† It may be observed that the writer's "Computation of Earthwork" contains tables from which the value of V, for several of the most usual side slopes, and for L = 100 feet, can be immediately found for given values of S and of γ. By the aid of other tables, V can be found by logarithmic computation.

in which, because σ is always greater than γ, we may replace $\frac{\tan.\gamma}{\tan.\sigma}$ by the sine of an auxiliary angle. Putting $\sin.\varphi = \frac{\tan.\gamma}{\tan.\sigma}$, that is, $\sin.\varphi = \cot.\sigma \tan.\gamma$, the above equation becomes

$$\text{V} = \tfrac{1}{4}\,\text{L}\,\text{S}^2 \frac{\cot.\sigma}{1 - \sin.^2\varphi} = \tfrac{1}{4}\,\text{L}\,\text{S}^2 \cot.\sigma \sec.^2\varphi. \quad . \quad . \quad \text{(D.)}$$

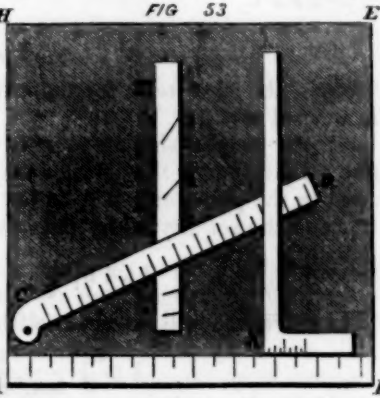
If A be the area of the base of a square prism, having the same length and the same solidity as the prism represented by equation D, then we have the equality $\text{L}\,\text{A} = \tfrac{1}{4}\,\text{L}\,\text{S}^2 \cot.\sigma \sec.^2\varphi$, whence the side of the square base is

$$\surd\text{A} = \tfrac{1}{2}\surd\overline{\cot.\sigma}\ \text{S} \sec.\varphi.$$

We do not design, however, to employ the quantity $\surd$A, but in its stead $\surd\text{A}\surd 8$. With this we shall enter a table containing the tabular quantity $\frac{1}{8}\,\text{L}\,(\surd\text{A}\,\surd 8)^2 = \text{L}\,\text{A}$, the content of the prism. It only remains to find $\surd\text{A}\,\surd 8 = \surd(2\cot.\sigma)\,\text{S}\sec.\varphi$, by the Tablet. The equation $\sin.\varphi = \cot.\sigma \tan.\gamma$, permits a ready construction of the angle φ. First take radius = cot. σ and, with this radius, find tan. $\gamma = \sin.\varphi$. Then with radius 1 take sin. φ and construct φ. If S be taken for radius, then S sec. φ will be shown by the secant of the angle φ. In order to obtain $\surd(2\cot.\sigma)\,\text{S}\sec.\varphi$, the secant shown by the Tablet must be measured by a scale, so graduated that the absolute length of its unit is to the length of the unit of S, as $\frac{1}{\surd(2\cot.\sigma)}$ to 1.

In the figure, A B E H is a flat tablet. The scale C D is the secant scale, movable about the pivot C, and is graduated as above described. It is set to its place by aid of the tangent scale T, which indicates the angle φ. The scale A B measures the sum of heights S, to which the square K, sliding against A B, is set. The back of the square contains a vernier, which reads to tenths of feet. The blade of the square marks the end of the secant upon the secant scale. Thus, if the side slope be $1\frac{1}{2}$ to 1, the surface slope 15°, and the sum of heights be 58, we shall read on the secant scale, say 109·7. Supposing L = 100 feet, $\frac{1}{2}\,\text{L}\,(109{\cdot}7)^2 = 150{,}426$ feet $= 5571{\cdot}3$ yards.* If L differs from 100 feet, our tabular content is taken proportionally (Equation B). The diagram represents this example.

FIG 53



If the surface slope is level, and the sum of augmented centre-

*See the example in Treatise at the bottom of page 48. The quantity 5571·3 will be found in table XV., opposite 109 feet, and under seven-tenths.

heigths $= s_2$, we may find the solidity of the prism with level surface slope from equation B. Then equating the value thus found with that given in equation D, we may find the sum of *equivalent level heights*, that is, a sum of equal heights which, under level ground, contain the same solidity as the prism under sloping ground. We shall have

$$\tfrac{1}{4} L s_2^2 \cot. \sigma = \tfrac{1}{4} L s^2 \cot. \sigma \sec.^2 \varphi,$$

whence,

$$s_2 = s \sec. \varphi.$$

Hence, if the scale C D be graduated like A B, by taking S upon A B we shall find s_2 upon C D; say, in the above example, 63·3. Hence, equivalent level heights may be correctly employed to compute the solidity under the proposed warped surface. We shall not here describe the manner in which we have applied this method.

By means of the Tablet, a sum of heights may be found which will contain, under a given surface slope, the same solidity as another given sum of heights under another given slope. Thus, suppose E K (fig. 45) to have been found = 14·5, and the slope of C M = 26°. Required the sum of equal heights which shall contain, under a slope of 8°, the same solidity as the prism upon C M E. The sum of two equal heights, E K, is 29. Set the square, K, of the Tablet at 29, and set the secant scale, C D, at 26°. Then read on this scale, say 73·7. Set the scale, C D, at 8° upon the tangent scale, T, and set the square, K, at 73·7 on C D. Then read the distance marked by the square upon A B, say 41·6, for the new sum of heights required. We shall presently want to make use of this number.

Put the augmented centre-height of the mid-section $= \frac{1}{2} s$, and its surface slope $= \gamma$. The solidity of the prismoid standing on that part of the mid-section included between the surface and road-bed will be, by formula C,

$$\tfrac{1}{4} L s_1^2 \frac{\tan. \sigma}{\tan.^2 \sigma - \tan.^2 \gamma},$$

which is the first term for the solidity of the work contained under the warped surface.

Let the height, similar to E K (fig. 45), which would contain the same solidity under the surface slope γ of the mid-section, as is contained in the prism on C M E, be put $= D_1$; then the sum of heights is $2 D_1$, and the solidity is, by formula B,

$$\tfrac{1}{4} L 4 D_1^2 \frac{\tan. \sigma}{\tan.^2 \sigma - \tan.^2 \gamma}.$$

The *correction* will be one-twelfth of this, equal to

$$\tfrac{1}{4} L \frac{D_1^2}{3} \frac{\tan. \sigma}{\tan.^2 \sigma - \tan.^2 \gamma}.$$

Combining this last with the expression just found for the first term, and observing that the correction may be either additive or subtractive, we have, for the solidity between the warped surface and the road-bed,

$$V = \tfrac{1}{4} L \left(s_1 \pm \frac{D_1^2}{3} \right) \frac{\tan. \sigma}{\tan.^2 \sigma - \tan.^2 \gamma}.$$

Making $s_1^2 \pm \frac{D_1^2}{3} = s'^2$, we have

$$v = \tfrac{1}{4} L s'^2 \frac{\tan. \sigma}{\tan.^2 \sigma - \tan.^2 \gamma}. \quad . \quad . \quad . \quad . \quad . \quad (E.)$$

Which is of the same form as equation B, and may be resolved by the Tablet in the same way. Equation E may also be resolved by equivalent level heights, or by any of the processes which, in our treatise, we have given for equations of this form.

As an example to be worked by the Tablet, take the following:*

First end-height, —28·7; surface slope, 18° to the right; second end-height, —14·5; surface slope, 12° to the left; side slope, 1½ to 1; road-bed, 24 feet; length, 100 feet. Required the solidity between the surface and road-bed (fig. 45).

The augmented height of the mid cross section will be found by construction = 34·96, which gives the sum s = 69·9. The surface slope will be found 8°. Then by construction we find, according to equations A and C, $s_1 = 68{\cdot}13$. We have found above for a prism equal to that upon C M E, and having a slope of 8°, the sum of the centre-heights = 41·6 = 2 D_1; hence, $D_1 = 20{\cdot}8$. The correction is subtractive; hence, $s' = \sqrt{s_1^2 - \frac{D_1^2}{3}}$ may be found by construction = 67·06.

Then set the square K, of the Tablet, at 67·06, and the scale C D at 8°, and read upon C D the distance, say 118·8. Then, $\frac{1}{9} L (118{\cdot}8)^2 =$ 176,418 feet = 6534 yards, which may also be found by our table XV.†

As the Tablet is only the mechanical adaptation of constructions we have taught in our work, this cubature is a geometrical solution for the warped surface proposed.‡ If the correction be neglected, the operation of the Tablet is very expeditious. The auxiliary constructions will be facilitated by the use of permanent diagrams, for which, in our treatise, we have given the rules of construction, and which can be rapidly prepared by an expert draughtsman.

The Tablet can be formed by pasting a paper scale, A B, upon the edge of a drawing table. The square K may be supplied by a T square applied to the edge of the table. The scales T and D may also be made of paper. The scale T should have its zero upon a line drawn through the pivot C, parallel to A B, which should also count from C. Means will readily be found to change these scales when a new side slope is employed. The writer has, for the tangent scale, made use of a polygonal roller let into the Tablet. On the faces of this roller, various scales may be graduated.

It is possible to reduce work having a triangular cross section, as in hill-side work, to a form proper for computation by the Tablet. In such cases, we may suppose A D (fig. 45), which may be imagined horizontal, to represent the road-bed, and A C the side slope: B C will be the surface. Then bisect the angle B A C, and measure the height A N.

* See Treatise, Example 2, Article 104, page 53; and Article 6, page 294.

† If considered preferable, the correction may be made by taking one-third of the tabular quantity corresponding to E K and the slope C M, as shown on page 294; using the Tablet.

‡ See Plate xiv. of Treatise, and text, Articles 23, 24, 25, Appendix.

This might be facilitated by drawing A N (sufficiently prolonged) on a permanent diagram, and graduating a scale upon this bisecting line. A line perpendicular to A N would represent the horizontal, in regard to the measurement (for the construction of the scales C D and T of the Tablet) of the side slope and the surface slope. This line would bisect the real angle of side slope. The surface slope which is to be used for constructing the scale T being called γ', and γ being the real surface slope, then $\gamma' = \gamma - \frac{1}{2}\sigma$. The level surface, as concerns the scale, will be when $\gamma = \frac{1}{2}\sigma$; this will produce the zero of the scale, or $\varphi = 0$. But this point must be marked with the original surface slope, $\gamma = \frac{1}{2}\sigma$, and so on. Two graduations will thus arise, one counting up the scale, the other down it. Each division of the scale should be marked with the degree of original surface slope to which it corresponds.

If the correction is omitted, or if the surface is plane, only the sum s_1 (equation C) will be required to be found by construction. The operation by the Tablet is then easy. As the accurate computation for plane ground is simple, we would not, when the ground is plane, or assumed to be so, reject the *correction* in practice. But for warped surfaces, we think it may answer to compute only the first term, or the prismoid standing on the mid area. For it must be observed, that the warped surface has not been demonstrated to enclose a solidity more nearly approximating the actual content of the ground than any other surface determined by the same data. In the absence of a demonstrated theory, it is even possible that the prismoid standing upon the mid area of the warped surface may, in the long run, be as good an approximation to the true solidity of the work, as the solid under the warped surface. The doubt which rests on the choice of the warped surface, justifies, in the writer's opinion, some remission of the labor of computing accurately under it, especially for preliminary estimates. Similar considerations would, of course, apply to other surfaces. As long as there is neither a demonstrated theory nor an authoritative decision to guide, engineers must, it seems to us, depend on individual judgment and experience, to determine when rules of computation are sufficiently accordant with the law of the assumed surface, and, also, when assumptions regarding the surface are sufficiently correct.

We do not, however, propose to enter here into a formal discussion of the most probable hypothesis concerning the ground surface, but shall merely further observe, that experience has convinced us that, whether a satisfactory hypothesis can be found, or not, it will be difficult to introduce into general practice, rules for earthwork computation, which are either very laborious, or which require a constant and considerable exercise of inventive faculty in their application. Hence, we are of opinion that rules for ascertaining, by preliminary calculation, under what circumstances this or that hypothesis is to be employed, will prove a failure in practice. It will be easier to divide the ground into shorter sections, and compute them by a uniform process. In the formation of practical rules, we have endeavored, both by study and by oral consultation, to ascertain the wants of the practical man, and to reconcile them with the theoretical exigencies of the subject.

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By JAMES A. KIRKPATRICK, A.M.

APRIL.—The mean temperature of April, 1862, was about 3½° below that of the same month of 1861, and 1½° below the average temperature of the month for eleven years.

The warmest day of the month was the 18th, of which the mean temperature was 70°, the maximum temperature (82°) being reached on the same day.

The coldest day was the 9th, with a mean temperature of 33·2°. The minimum (28°) was attained on the same day.

The range of temperature for the month was 54°.

The temperature was below the freezing point on but 3 days of the month, namely, the 8th, 9th, and 10th.

The greatest change of temperature in the course of one day was 27° on the 17th day of the month; the least was 7° on the 21st. The average daily oscillation of temperature (17·87°) was a little more than one degree less than that of April, 1861, and about one degree more than the average for eleven years.

The greatest mean daily range of temperature (that is, the greatest average difference of temperature between one day and that immediately following or preceding it), was 14°, between the 18th and 19th of the month; the least was 1·8°, between the 26th and 27th. The average daily range for the month (5·89°) was almost identical with that for April, 1861, and was about half a degree below the average for eleven years.

The pressure of the atmosphere was greatest (30·321 inches) on the morning of the 16th of the month; and least (29·422 ins.) on the afternoon of the 22d. The greatest daily mean pressure (30·300 inches) occurred on the 15th, and the least (29·439 inches) on the 22d. The average pressure for the month (29·999 inches) was 0·183 of an inch greater than for April, 1861, and 0·194 of an inch greater than the general average for eleven years.

The greatest mean daily range of atmospheric pressure was 0·3 of an inch, and occurred between the 21st and 22d days of the month; the least was 0·044 of an inch, between the 26th and 27th. The average mean daily range for the month (0·146 in.) was 0·025 of an inch less than the average for April for eleven years.

The force of vapor was less than usual. It was greatest (0·555 in.) on the 18th, and least (0·091 in.) on the 7th of the month. The average for the month (0·219 in.) was about two-hundredths of an inch less than the general average.

The relative humidity was greater than for April, 1861, but less than the average for eleven years. It was greatest (94 per cent.,) on the morning of the 9th of the month, during a snow storm, and least 18 per cent.) on the afternoon of the 27th. The average humidity of

for the month was about 2 per cent. more than for April, 1861, and 3 per cent. less than the general average for eleven years.

Rain or snow fell on eleven days of the month, to the aggregate depth of 3·947 inches, which is one-fifth of an inch less than fell in April, 1861, and nearly one inch less than the average amount for eleven years.

There were three days of the month, the 11th, 12th, and 27th, entirely clear or free from clouds at the hours of observation, and the sky was completely covered with clouds at those hours on five days. The average amount of the sky covered with clouds during the month of April, 1862, was about 62 per cent.; during April, 1861, it was 53 per cent., and the average amount for eleven years is 60 per cent. of the hemisphere.

A snow storm commenced about 9 A. M. on the 8th, and continued until 8 A. M. on the 9th, when there was about three inches of snow on the ground. It commenced again about half past 2 on the afternoon of the 9th, and continued until 6½ A. M. of the 10th, when the snow had attained the depth of about 12 inches. This was the last snow of the season.

A Comparison of some of the Meteorological Phenomena of APRIL, 1862, *with those of* APRIL, 1861, *and of the same month for* ELEVEN *years, at Philadelphia, Pa.* Latitude 39° 57½′ N.; Longitude 75° 10½′ W. from Greenwich.

	April, 1862.	April, 1861.	April, 11 Years.
Thermometer.—Highest,	82°	88°	88°
" Lowest,	28·0	33	20
" Mean daily oscillation,	17·87	19·05	16·89
" " daily range,	5·89	5·85	6·40
" Means at 7 A. M.,	44·57	47·18	45·63
" " 2 P. M.,	55·23	60·55	57·51
" " 9 P. M.,	48·28	51·10	49·45
" " for the Month,	49·36	52·94	50·86
Barometer.—Highest,	30·321 in.	30·233 in.	30 518 in.
" Lowest,	29·422	29·213	28·884
" Mean daily range,	·146	·143	·173
" Means at 7 A. M.,	30·025	29·845	29·824
" " 2 P. M.,	29·979	29·787	29·782
" " 9 P. M.,	29 994	29·816	29·808
" " for the Month,	29·999	29·816	29·805
Force of Vapor.—Means at 7 A. M.,	·211 in	·231 in.	·233 in.
" " " 2 P. M.,	·219	·226	·247
" " " 9 P. M.,	·228	·259	·250
" " " for the Month,	·219	·238	·243
Relative Humidity.—Means at 7 A. M.,	67·8 per ct.	66·9 per ct.	71·8 per ct.
" " " 2 P. M.,	48·5	42·3	51·3
" " " 9 P. M.,	64·5	65·3	67·5
" " "for the Month,	60·3	58·2	63·5
Rain and melted snow, amount	3·947 in.	4·150 in.	4·799 in.
No. of days on which rain or snow fell,	11	9	12·8
Prevailing winds—Times in 1000-ths,	N.45°0′ E. ·047	N.73°30′W·177	N.68°5′ W.·161

BIBLIOGRAPHICAL NOTICE.

A Report of the Lighthouse Board in relation to the Transfer of the Lighthouse Establishment to the Navy Department. 37 Cong., 2d Sess., Senate. Mis. Doc., No. 61.

In the year 1851, the lighthouses of the United States were in a condition which was disgraceful to our country. Along the whole of an extremely exposed and dangerous coast, there were in all but 325 lights; of which one was ranked as of the 1st, two of the 2d, and 16 of the 3d order. But these were of the old reflector pattern, which had been long abandoned by the maritime nations of Europe for the refracting system introduced by Fresnel. Organization of the service there could scarcely be said to be any. The whole matter was under the control of one of the Auditors of the Treasury Department, whose other duties were quite as much as he could attend to; and, as the management of the lighthouses brought with it less political influence than any other branch of his duties, it was of course entirely neglected, except to give a favorite supporter a fat contract for furnishing oil in wasteful quantities at unheard-of prices.

When we consider how important an efficient system of coast-lights is, as well to the pecuniary interests of our merchants as to the character of the nation itself as one of the community of civilized nations, we will easily understand that this state of things was bitterly complained of, and so in 1845, two intelligent officers of the Navy were, at the request of the Hon. R. J. Walker, then Secretary of the Treasury, detailed to visit and examine the lighthouse systems of England and France; and afterwards, in 1851, another commission was appointed to examine into the lighthouse establishment of the United States. It will be seen that the matter was not hurried. But upon the report of this latter commission, Congress passed an act establishing the Lighthouse Board, consisting of "two officers of the Navy of high rank; one officer of the corps of engineers of the Army; one officer of the corps of topographical engineers of the Army; and two civilians of high scientific attainments, whose services may be at the disposal of the President; and an officer of the Navy, and an officer of engineers of the Army as Secretaries."

The two civilians appointed on the Board were Prof. A. D. Bache, Superintendent of the Coast Survey, and Prof. Joseph Henry, Secretary of the Smithsonian Institution.

The propriety of the appointment of just such a board as is here provided for will be seen by a moment's reflection on the requisites of the service. The first point is to arrange the approximate positions of the lighthouses, so as to insure general security along the whole coast, as well as a special care for the safety of any peculiarly dangerous positions. This falls within the province of the Navy, although it would seem that it might be at least as well done by the Revenue Department, or by two merchant captains of the coasting trade. The next point is the selection of the precise site for the lighthouse; and as this requires an intimate knowledge of the coast, both inland and within soundings; of the position, extent, and depth, of all shoals and

banks, and a minute acquaintance with the force and direction of all the currents, both constant and temporary, in the vicinity of the locality, there is but one place in the whole country to which we can apply for the requisite information, and that is the Coast Survey. When the locality is determined on, the next point to be attended to is the erection of the tower, and this requires such thorough and extensive engineering ability, that not a few of the great engineering reputations of England have for their foundation the successful establishment of lighthouses in difficult positions. The next and most important point is the light itself, wherein are to be considered several problems: to obtain the most intense light; to concentrate it into a parallel or slightly divergent beam; to avoid throwing any part of it away in directions where it can be of no use, such as upwards, downwards, or landwise; to prevent as far as possible the absorption of it by the apparatus used for concentrating it; to give it such a character that it may be readily distinguished by the mariner, so that when he sees the light he may know exactly whereabouts on the coast he is. Now these are problems of Physics; they lie neither in the province of the engineer, the mariner, nor the surveyor. They are problems whose solutions are being every day more and more perfected by observations and experiments and discoveries taking place in all parts of the civilized world. To meet this want, then, we require a man of high scientific ability and attainment, one who is accustomed to read all the scientific journals of the world, so that no discovery can escape him; and one who is himself able experimentally to test the correctness of results said to be reached, and to develop such new ideas as may occur to himself; and, in addition, one who knows the abilities of the various scientific men of our country, so that he may employ their knowledge and facilities where it may be desirable to use them. Such a man pre-eminently is Prof. Henry.

It appears, therefore, *à priori*, that the lighthouse board was judiciously constituted; it appears so still more clearly from the facts reported to the Senate in the document before us.

The number of lights has been increased from 325 in 1852 to 556 in 1858; the character of the lights has been improved by the introduction of all the last improvements, so that in place of being a disgrace to the nation, our system will now favorably compare with those of England and France; yet, notwithstanding this greatly increased number and efficiency of the lights, the cost of maintaining them was less in 1858 than in 1852 by $184,720. The whole system has been organized, a proper superintendence established over the keepers, so as to insure the utmost efficiency and regularity in each light, a matter which can hardly be properly appreciated except by the mariner.

Let us hope, then, that seeing how admirably their experiment has succeeded and is succeeding, and having regard to the fact that this wicked rebellion has extinguished 125 lights, many of them of the highest importance, which must be immediately replaced,—let us hope that Congress will not be induced to make any change whatever in the lighthouse department, until they are thoroughly satisfied that there is an evil to be remedied, and that the remedy which they propose to apply is the right one.

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